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DISINFECTANTS

AND DISINFECTION

BY

ROBERT ANGUS SMITH,

PH. D., F.R.S., F.C.S.

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NOTE.

This volume contains a record of my own experience in attempting to obtain results by exact methods hitherto untried. Most of it has already appeared in print in my Report to the Cattle-Plague Commission, and in articles contributed to different Journals.

Manchester, *January* 1869.

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DISINFECTION.

GENERAL AND INTRODUCTORY.

DISINFECTION is an art borrowing its knowledge from chemistry. Some day it may rise into a science. We may then suppose it to be a division of Colysis. The first division may be made to include *Anæsthetics*—substances which restrain the vital action in animals; the second may include *Antiseptics*—substances which prevent decay in animal and vegetable matter, for use, beauty, or sentiment; the third, *Disinfectants*—substances which prevent or remove the corrupt state of organic bodies, solely to prevent them injuring the atmosphere. They are all probably one, and the second and third are clearly so in principle, but in practice they are connected with very different conditions of things. We cannot separate these two in taking a survey of the subject as it stands.

A Greek friend showed us a few months ago a small vessel, from the tomb of an ancient Athenian, and shaped not very unlike our pots of pomade. The lid fitted on in a loose way, as is the case with our own earthenware manufacture for the toilet-table, but the material was porous. We opened it, and strange to say the odour of attar of roses was distinct. We are informed that it was so when the tomb was discovered. This narthex, as we suppose it would be called, was not shattered, or even broken, but it illustrated Moore's verses better perhaps than anything known, and brought to our minds the passion for odours and unguents that seems to have possessed the most refined senses of the ancient world. The scents were used as a luxury, but it is extremely probable that the fashion was fostered as a means of removing the unpleasant odours arising from persons who slept in the clothes which they wore during the day; many of these had no convenience for washing, notwithstanding the habit of bathing among others; and this opinion is confirmed by the fact that during all epidemics, perfumes and substances with decided odours, agreeable, or not very much so, were everywhere employed as disinfectants.

It is pleasant to enter Greek houses for those who like to find at every visit some new preserve, some new fragrance kept in sugar, some new fruit saved from decay by drying, or by syrup. We have never in the North made the rose into a delicious dish for breakfast, but this they have done in Greece; and they still preserve the fruit of the pines, making a compound that astonishes and delights our palates, and still more so when we think that this seems handed down from the ancients. True, we have not the stone pines, cones grow less luxuriantly with us, and do not produce kernels of a nourishing quality, as Athenæus tells was their character in old times, as now in Greece. Or are we less ingenious? When we enter Greek houses, or read that last-named author, we are inclined to think that we have lost the art of preserving, and require to be taught.

Conservation of food is a kind of disinfection; it is a prevention of infection. The art of preserving food has grown slowly with us, by the aid of many patents, some of which are successful. They aim chiefly at driving out the oxygen of the air, either by steam, or by the use of other gases which take its place. The older plan of preserving by the use of sugar is far beyond the reach of patents, and is well used in this country for many purposes, although these purposes, as we believe, may be made very much more numerous.

The preservation of meat is not yet brought to perfection, otherwise the cattle of distant parts of the world would be brought into our markets. Flesh becomes infected rapidly, and we require to invent new modes of disinfection in order to increase the supply of meat in this country, and thereby enable us to keep up that physical strength which always was a characteristic of a Briton, and which seems to be the main cause of his energy and success. It is not at all clear that in this department we can have any aid from the ancients. We are able to leave them when we arrive at the preservation of animal food; but if it is some pleasure to do so, it is not with perfect satisfaction, because we are aware that we ourselves have not made such progress as to allow us to boast.

Indeed, there is a department, namely, that of the preservation of the human body from decay, in which we find Egypt to have excelled the world, and to an extent which must ever be one of the wonders of history. A dry climate was a great aid; but even taking that into consideration, the work was well done. They removed the parts of the body which had least tenacity and most moisture, as these are invariably found to decay most rapidly.

In very warm and dry countries, preservation of thin pieces of flesh can be made by mere exposure to the sun. The moisture is removed before corruption begins. The mode of cutting it into stripes and laying it out to dry is therefore adopted. It is marvellous what small changes in the atmosphere affect the success of this plan. It is said on the La Plata, where this is sometimes done, that if a small cloud appear on the horizon, no bigger than a hand, the drying will not be effected before corruption begins. This is not quite intelligible to us. It is true the cloud is the barometer, and tells us that the moisture of the air is increasing, and we know that moisture increases putrefaction and decay, as well as vigorous growth. Our difficulty lies in understanding why such a small amount should have such a powerful effect. This, however, we know, that however powerful a disinfectant may be, its strength will be diminished by increasing the amount of water.

It is, however, remarkable that bodies are preserved in some conditions without any adequate apparent cause. It is not clear why the bodies at the chapel near Bonn are kept from corruption. It is said that no means of preservation are used, and the only cause seems to be a constant draught of air blowing through the place. Bodies have in many cases been preserved without decay in Europe, when it has not been known that any embalming has been used. We are told that coffins have been opened in which the bodies appeared as if they had never changed from the time of burial, but by a few minutes' exposure fell down into a small heap of dust. This may happen also when embalming is faulty. The kings of France at St. Denis are said to have undergone that rapid change. The bodies found in the earthenware coffins by Loftus, and described in his most interesting travels in Chaldea and Mesopotamia, were found also to fall into dust. There does not seem in such cases to have been any chemical action of the air at the moment of opening, but, in all probability, the slightest motion was enough to throw down the dust to which the bodies had long ago been reduced. The air gradually entering would bring out with it all the animal matter, united with oxygen in the form of carbonic acid, and the earths, phosphates, and substances not volatile would remain, not contracted into hard ash, as may occur when we burn it, but simply as they existed diffused through the structure of the flesh.

We are still unable to explain the meaning of the vampires, as those bodies were supposed to be, which were so fully preserved as not to fall to ashes when the coffin was opened. It was needful to destroy them by passing a stake through them. We cannot look on the whole as untrue. The fabulous portion seems to be confined to the saying that such bodies rose at night and demanded others. In connexion with this, we know that many of the older places of burial, or at least vaults and catacombs, were so badly supplied with air, that possibly the atmosphere surrounding the bodies became after a time of itself preservative. We know that in the Catacombs of Paris it gave rise to a new transformation of the elements, and instead of the dead decomposing into gas and ashes, they, from want of suitable air, were converted into adipocere, a white waxlike substance.

Many people think that we ought, like some of the ancients, to burn our dead. They do not consider what a terrible proposal they are making. To burn a body without producing the smell of burning flesh is a most difficult thing, and far surpasses the problem of burning our smoke, which, however important, is still left undone. The expense of keeping up such a lake of fire as to consume all our dead would also be, in all probability, too great; let us imagine 1500 bodies roasted to ashes in London every week. We shall not enter into the details of such a large manufactory of phosphates, as we must call it, because it is painful to dwell on the horrors of the picture, and conjure up the details.

In all nations the practice of burning has been found too expensive. In India it is really practised only by the rich. The poor can only afford a little wood, which burns as a formality to satisfy the demands of their faith. In no greatly populated country can it be practised by the poor. Fuel has for all cases of this kind been too dear, and is so even with us.

When bodies are allowed time and space to mingle quietly with the earth, the products given out are by no means unpleasant; neither, in the small amounts gradually emitted, can they ever be said to be unwholesome. Nor can we blame our ancestors much for allowing their illustrious dead to be buried in their churches. It began to be an evil only when the charity of man increased, and when the respect towards humanity extended itself even to those who could not be called illustrious, and the increase of the living induced that crowding among the dead which legislation has of late almost entirely caused to cease.

We read in the Bible of the great care taken to disinfect or clean vessels in which any putrid matter may have been, and we trace clearly the effect of early observations on its action on absorbent substances: vessels of iron and of wood were differently treated. The same may be observed as to the infection of walls covered with an absorbent plaster, and of clothes. We see clearly how the world must have suffered before the cause could have been traced to these simple properties of bodies—porosity and power of absorbing. We see also how towns must have fearfully suffered before they learnt that the houses must be so far separate as to allow air to blow between them. The Greeks must certainly have made their cities and many of their streets exceedingly handsome, but their earlier towns, and even Athens, were too much crowded; and so much did they fear jobbery among the sharp-eyed business men of the city, that they dared not trust any one with money to rebuild the place, as is now being done in Paris, in Glasgow, and in Edinburgh. In Constantinople, Zeno ordered all houses to be twelve feet apart all the way up, and the projections which caused the houses nearly to meet above were disallowed. This was an effort, after a long interval of neglect. He attempted also to go further, and ordered that no one should stop the view of the sea from his neighbour. This would be well in our sea-bathing towns, where houses are built before others without pity, and not only is the view destroyed, but the whole living of the families who possess it, and to whom the view paid the rent. But laws are of no value unless a strong and vigilant executive attends to them. Constantinople became so bad that its destruction by fire was scarcely deemed a misfortune.

How infected by their own crowding the Romans must have been when the houses were ordered to be at least five feet apart, and not more than nine storeys high! Augustus said they should not exceed seventy feet in height, and Trajan made the limit sixty. The laborious proofs that sewer air is unwholesome have taken Commissions and Boards of Health many years of hard labour in our time, but the whole is so clearly recognised in Justinian's Digest, in quotation from Ulpian, that it is evident that the question was then past all dispute. The world is obliged occasionally to revive its principles.

However true may be the opinion that man is always in progress, we cannot deny that he often makes, in certain places, wonderfully long steps backwards. Although Hippocrates is praised for his skill, shown in fumigating the streets by the smoke of fires and by perfumes, by shutting certain windows and opening others, one of our prominent men in the seventeenth century is found speaking with approval of killing "pigeons, cats, dogs, and other hot animals, which make continually a great transpiration or evaporation of spirits which issue forth of evaporation: the pestiferous atoms which are scattered in the air, and accompany it, used to stick to the feathers, skins, or furres" (Sir Kenelm Digby).

We, as a nation, have gone backwards and forwards as the ancients did, and in a generation we have many waves of opinion, because we do not learn sound principles, or, if we learn, we do not teach them, that they may be continued.

POINTS IN THE HISTORY OF DISINFECTION.

The word *infection* has from early times beeu used in a bad sense, although it means only the power by which one body acts in its own peculiar method on another, or the action itself. In the history of words we have the thoughts of the men who formed them. This word shows the ancient method of viewing the subject to have been little different from our own. The word *disinfection* took its origin, I imagine, in France during the last century,—at least I don't know of it sooner; it is applied to the removal of all disagreeable gases and odours, as well as to the decomposition which produces them; it therefore includes deodorizing. The use of the word in this manner is quite in accordance with the opinion held from the earliest ages, that the infection of fever or plague was either the same as, or distinctly allied to, these gases. In ancient times the prevention of corruption was more studied than actual disinfection ; bodies preventing corruption are properly antiseptics, and this is the name under which, during the last century, and great part of this, disinfectants have been chiefly classed in England.

The use of drainage as a disinfectant is from time immemorial, or the days of Hercules, who saved the Elians from pestilence by draining their marshes. Many instances of this occur in early times ; it is even probable that it was known before the time at which it has been supposed Hercules existed. Hippocrates studied these matters, and takes such a wide view of them that there is no doubt of his having received much of his cultivation from a fund of knowledge which one man could not accumulate. He is perfectly aware of the infectious nature of certain districts and of certain winds, and his views on the situations of towns, with regard to heat and cold, moisture, dryness, and exposure to winds, show a width of observation which for a long time the world has contracted into much smaller limits.

The disinfection of the streets and sewers was the duty of a high officer at Rome. "The prætor took care that all sewers should be cleansed and repaired for the health of the citizens, because uncleansed or unrepaired sewers threaten a pestilential atmosphere, and are dangerous" (Digesta Just., Lib. 43, tit. 23); it was forbidden to throw refuse on the roads (tit. 9). This cleanliness seems to have come from the East, where now only the ceremonial part remains; the streets of Jerusalem were said to be swept every day, although a place not considered greatly advanced in the arts. There can be no question that in these respects the world had at one time receded very much, and moderns, whilst gaining ground for themselves, have been compelled also to struggle for much that ignorance and idleness had lost. In the twelfth century Paris had neither a pavement nor street-sweepers, nor had it even a place into which to carry the refuse. We read in the French Dictionary of Hygiène, by Tardieu, that the filth of the streets stirred up by the horses' feet so disgusted Philip Augustus, that he ordered pavements to be made. Nor was London any better. We have only to imagine the condition of certain small towns of modern times, to give an idea of the state of great capitals left in a neglected condition. Even up to last century, we read of dangerous riots in Paris, caused by the proximity of great masses of filth, which an indignant public refused any longer to endure.

Many arts have undoubtedly been lost, because in early times care was not taken to make them so well known and so necessary to comfort, that the destruction of a capital city or even of an empire, would be unable to root them out of the minds of the remaining population.

The use of antiseptics, as applied to the dead, has been known longer than any authentic history which books have handed down, and some of the processes described to us by persons who saw them carried on in a manner transmitted to them from very early ages, show us that in the chemical arts there has been a loss of information, which has only been reproduced after much search and difficulty. I shall not describe the process of embalming, it has become familiar to all; but one or two points are interesting. They used resins, pitch or tar, and aromatics. They washed the body with natron and cedar oil. This natron or nitre was, in all probability, as Hoefer supposes, caustic soda.

When caustic soda was made, they seem to have sold the lime and soda together, as it is said that the "pure was very easily dissolved, and the impure very pungent," meaning, I suppose, that the impure was not soluble on account of the lime. With the soda, oil of cedar was used. This has been called, with good reason, turpentine, which has strong disinfecting properties; but the word has evidently been used in many senses, as there are many liquid products to be obtained from cedar. It is used of the first liquid from the distillation of wood; and Berzelius, for that reason, says that the Egyptians used the pyroligneous acid, which, containing some kreasote, was a great antiseptic. But mixing this with caustic soda would be of little value, nor is it probable that they would add a volatile liquid like turpentine along with soda. It is expressly said by Pliny, that pitch was reboiled in his time, or, in other words, the tar was boiled and distilled into fleeces, from which the product was pressed. In doing this, the light oils of naphtha would be evaporated, and the heavy oil of tar containing the carbolic acid would remain. It was also called *picenum*, as if made of pitch, or *pissenum* and *pisselaeon*, or pitch oil, a more appropriate name than that of Runge's, who called it carbolic acid, or coal oil; and still more appropriate philologically than the most recent, which, by following up a theory, has converted it to phenic acid. The distillation was made in copper vessels, and must have been carried very far, as they obtained a "reddish pitch, very clammy, and much fatter than other pitch." This was the anthracene, chrysene, and pyrene of modern chemists. The remaining hard pitch was called *palimpissa*, or second pitch, which we call pitch, in contradistinction to tar. By the second pitch was sometimes meant the residuum in the copper still, and sometimes the product of distillation. A good deal of confusion therefore results. The pitch oil was resiny, fat, and of a yellow colour, according to some descriptions. They do not seem to have separated the last products well. This kreasote they used for toothache—a mode of disinfecting living bodies—as well as for skin diseases of cattle, for which it has been found valuable. Hams were smoked by it.

Of course this information is not got in so many words from Pliny, but it is remarkably clear. As Pliny got his information second-hand, he did not write so clearly as to be understood by a person not previously acquainted with the details. In all nations the burning of incense may have had originally a connexion with physical purity or disinfection, but so far as I know, the act of Ulysses is the earliest instance of direct fumigation for sanitary purposes—(*see under* Sulphur.) It was probably, also, partly religious. It seems to have been a common practice in Homer's time. The Italians have been obliged to re-discover the use of sulphur for their vines, and they find its value, although it takes away the fine flavour of their wines for a season, probably because it is carried to excess.

Honey was used as a preservative by the ancients, as sugar now; it is even said to have been used as an antiseptic in preserving the dead, and for specimens, as alcohol with us, as we read of a centaur which was born in Thessaly, but, dying the same day, was sent preserved in honey to a museum, as we should call it, in Egypt.

They used bitters to preserve new wines, somewhat as we do hops.

Fire was used in various ways as a purifier. It was used directly in times of plague for purifying and renewing the air of towns, accompanied with perfumes and flowers, as well as vinegar and various aromatic substances, amongst which may be put pepper, mustard, and so on. The use of perfumes was carried to an extent not dreamed of here, evidently a substitute in many cases for refined cleanliness, but not entirely, if originally so, because it became associated with the most refined habits, and generally with the purification of the bath.

Water, as a principal agent in disinfection, was highly appreciated by the ancients, and the most violent exertions of these late years have only put us on a level with the provincial towns of the Roman empire. Fire, as a great purifying agent, has everywhere had a prominent place, in some respects the most prominent, as it deserves to have, so that purification by fire may signify now, as it did of old, both in a physical and moral sense, the utmost state of disinfection. The fine observers on the Mediterranean had connected the departure of disease with the warming and drying influences of the sun, although it was also observed that the warmth and moisture of a south wind "tended to corruption," which was reversed by the invigorating north wind. In these opinions we have their knowledge of the disinfecting agency of heat and cold. They knew, too, from experience, that disease might be prevented by blocking up the windows towards an infected district, and opening others with a better view. Their use of drying in the embalming process is another indication of their knowledge of the agency of water and of heat.

That great disinfecting agent, the soil, was not forgotten, and indeed all nations have used it, more or less, for their dead. To bury is generally the most ready mode of disposing of dead bodies. When the power of the soil is complete, we look in amazement at the amount of dead which our burying-grounds absorb before they themselves become pestilential.

Whilst the ancients used various methods of preventing unwholesome decomposition in dead matter, they did not neglect the important object of putting a stop to the analogous decomposition in living matter, often the occasion of much pain. They had as many plans of curing toothache as we have, real and fancied; but Pliny mentions a method of removing a tooth without pain, by first making it anæsthetic. To this pitch we have only lately attained; although not using frankincense and oil of roses. Although we may not be able to use their processes, we must not deny all. The description is not very exact, but the mere idea proves advance. Philip Beroaldo, in his annotations on Galen, says, "The kind of fishes called by Galen and other writers *narké*, the translator has very absurdly termed *stupor*, because in Greek *narké* does at other times mean stupor, whence the term in medicine, narcotics, which we use in cutting off limbs, producing a stupor so that *the amputation is made without pain.*" He speaks in the fifteenth century, as if the subject were well known, whilst to us it is a great novelty, which we imagine to have been waiting till such time as chemistry should discover the proper materials.

The modern history of disinfectants began, conveniently speaking, in the seventeenth century. Boyle worked a good deal on kindred subjects, and showed the influence of air and of heat and cold. In 1732, Dr. Petit made experiments on antiseptics; he used small portions of mutton, and found how long each antiseptic preserved a piece untainted: he came to the conclusion that astringents were the best, and that their action was similar to drying. He illustrated it by saying that, as corruption comes from the separation of the particles, so preservation is attained by contracting them, or drawing them closer, as is done by dry air and astringents.

In 1750, Sir John Pringle wrote his "Experiments on Septic and Antiseptic Substances, with Remarks relating to their Use in the Theory of Medicine." He recommends salts of various kinds, and astringent and gummy resinous parts of vegetables and fermenting liquors. Dr. Macbride followed him with numerous experiments. He speaks of acids being the long-prescribed agents as antiseptics. He found that even diluted to a great extent they were powerful; that alkalies were antiseptic; that salts in general have the same quality; also "gum-resins, such as myrrh, asafœtida, aloes, and terra japonica;" also "decoctions of Virginian snake-root, pepper, ginger, saffron, contrayerva root, sage, valerian root, and rhubarb, with mint, angelica, senna, and common wormwood." Many of the common vegetables also were included as to some extent antiseptic, such as horse-radish, mustard, carrots, turnips, garlic, onions, celery, cabbage, colewort. Lime was found to prevent but not to remove putrefaction. Animal fluids, he observes, will remain for a long time without putridity if kept from the air. He says that astringent mineral acids and ardent spirits "not only absorb the matter from the putrescent substance, but likewise crisp up its fibres, and thereby render it so hard and durable that no change of combination will take place for many years." To add molasses to this list, will complete fairly a description of his opinions.

In 1767 an essay recommending nitrate of potash in ventilation received the recommendation of the Academy of Dijon. How this was applied, the *Dictionnaire de Médecine*, from which I have taken it, does not say.

In 1773, Guyton Morveau proposed fumigation with muriatic acid vapours as a mode of disinfecting hospitals, etc. This was held as a great discovery at the time, and practically acted as a valuable step. He adduces the testimonials of men deservedly great in our estimation, to prove the excellence of his method. It was even stated that the fumes were not disagreeable. He was much aggrieved when Dr. Carmichael Smyth used nitrous fumes at Winchester, in 1780, and afterwards in the Fleet, without giving him the credit of the discovery of acid fumigation. And still more was he hurt when Parliament, in 1802, voted £5000 to Dr. C. Smyth. But he tells us that *even* in England he found men to do him justice. Let us do him justice; he seems to have been the first that introduced acid fumigations in modern times; still the disinfecting power of acids was known before. Where were our classical scholars, and why did they neglect the ventilation by acid fumes, so frequent in Greece and in Rome, and distinctly written in their beloved Homer? Muriatic acid is very inferior as a disinfectant, and even in Guyton Morveau's mind it soon gave way before chlorine, which was introduced as a fumigating agent in 1791-2 by Fourcroy. This last gas was introduced into England by Dr. Cruikshank.

The Danish method of fumigation is by the use of muriatic acid. Common salt may be used, by pouring vitriol on it without heat, but nitric acid may also be used, it is said, which, however makes a great alteration. It is well to give Guyton Morveau his full due. The Chancellor of the Legion of Honour, writing to him in the name of the Emperor Napoleon in 1805, says, "Europe and America know that since 1773 you have employed your discovery of the application of muriatic acid fumes to arrest the effects of contagious and direful diseases." He obtained for it the brevet of an officer of the Legion of Honour. This is in the preface to the "Traité des Moyens de désinfecter l'Air, de prévenir la Contagion, et d'en arrêter les Progrès," 1805.

Hildenbrand found that meat in a vessel of oxygen putrefied in eleven hours. By the consent of all times the contact of putrid matter assists it, although some have demurred to this, mentioning that sulphide of ammonium prevents putrefaction; but this only happens when the liquid is very strong. Berzelius says that animal liquids may be long prevented from decay by occasional heating to 100° C. or the boiling point, in order to remove the oxygen when absorbed. Another writer says 60° C. or 140° F. Sweeny preserved meat in water by first boiling out the air, cooling it, covering it with a stratum of oil to keep out air, and adding iron filings to absorb what might have been allowed to enter. Meat remained sweet in this way for seven months. Leuch added a covering of oil also, but used unboiled water and sulphur instead of iron filings. Meat was preserved in this way for two months.

Putrefaction is said to be rapid at 10° C. or 50° F. under water, but in the air the same rapidity is not attained till 25° C. or 77° F.

Albumen coagulates at about 140° F. Some of the disinfecting agents coagulate albumen. Coagulation does not prevent although it delays putrescence.

Dr. Henry (in the *Philos. Mag.*, 1831 and 1832), showed that at a temperature of about 140° Fahrenheit vaccine matter had entirely lost its peculiar properties. He kept up the temperature for three hours. If heated for three hours at 120° Fahrenheit, it still retains its vaccinating properties. This matter, if allowed to stand, would then undergo ordinary putrefaction. Dr. Henry also showed that the clothes of fever patients were disinfected by exposure for one hour to a temperature of 200° Fahreuheit.

THE DANGERS TO BE AVERTED.

An old writer, Mr. Place, in a book called *A Hypothetical Notion of the Plague*, says :—

" The manner of the pestilential matters' operation is called ' contagion,' or ' infectiou,' aud, by a metonymy, putting the cause for the effect, we usually call the matter itself so, as having the virtue of contagious operation in it."

He continues,—

" Infectious or contagious virtue and operation, then, is an assimilating quality and conversive force in the matter to change the nature of things by turning them into its own. When by immediate contact one body alters the properties and changes the natural inward form and constitution and disposition of another, and works it to conformity to itself, draws it into its own likeness, impressing its own character upon it, and communicating to it its own form and figure,—matter that has this virtue of operation is called infective or contagious, and the matter that is violently drawn and forced by it out of its form is said to be infected."

This is remarkably similar to the expressions used by Liebig, in his work on " Agricultural Chemistry," where he says :—

" But if it is true, as we have just shown it to be, that mechanical motion is sufficient to cause a change of condition in many bodies, it cannot be doubted that a body in the act of combination or decomposition is capable of imparting the same condition of motion or activity in which its atoms are to certain other bodies; or, in other words, to enable other bodies with which it is in contact to enter into combinations or suffer decompositions." We see here the maturer mind of the modern man of science.

To a chemist, then, infection is the process by which a chemical action is transferred through one body to another, whether by the agency of organic bodies or otherwise. When a putrid substance comes in contact with a sound substance, and communicates putrefaction to the latter, it is a process of infection somewhat similar to the communication of disease by the contiguity of a diseased to a healthy person. The communication may be supposed to be made by chemical compounds, organic, but not organized.

A physiologist and microscopist is inclined to give organized form to the agents of his mind, and nature seems to be inclined to suit this class of men as well as the chemist, and for this reason we are led into the great discussion on the cause of fermentation and putrefaction, ending in the late inquiries into the probability of spontaneous generation. I certainly fancied that I was giving good service by proving the presence of organic and oxidizable matter in the air by the use of permanganate of potash, but the results obtained by M. Pasteur regarding the existence of organized substances, as we may call them, or germs, is a step so definite, clear, and important, that we must at once begin as on a new foundation, and date theories of many diseases, and also of disinfection and cure from this era. I do not mean to say that the idea was utterly unknown to the world. I may quote Bishop Berkeley as saying the truth in wider terms than those used, so far as I know, by Pasteur, but he must stand in relation to the Frenchman as Mr. Place did to Baron Liebig, clear-sighted, thoughtful, ever great, but unable to reach the great aim of scientific inquiry, the *experimentum crucis.*

The words in Siris are (par. 140)—

"Nothing ferments, vegetates, or putrefies without air, which operates with all the virtues of the bodies included in it, that is, of all nature. . . . The air, therefore, is an active mass of numberless different principles, the general sources of corruption and generation; on the one hand, dividing, abrading, and carrying off the particles of bodies, that is, corrupting or dissolving them; on the other, producing new ones into being, destroying and bestowing forms without intermission."

And in paragraph 141 he says:—

"The seeds of things seem to be latent in the air, ready to pair, and produce their kind whenever they light on a proper matrix. The extremely small seeds of ferns, mosses, mushrooms, and some other plants, are concealed and wafted about in the air, every part whereof seems replete with seeds of one kind or other. The whole atmosphere seems alive. There is everywhere acid to corrode, and seed to engender. Iron will rust and mould will grow in all places."

The tendency of inquiry in modern times has been to establish a very ancient belief, that decomposing substances, animal and vegetable, produce disease, and are ultimately connected with infection and contagion. This result may be said to be the summary of all that has been done by the General Board of Health and Sanitary Commissioners of late years. It is true that some persons object to these conclusions, and there are even many who have attempted to prove that the gases from decomposing substances were beneficial to health. The fancies or superstitions of the population have somewhat assisted this latter retrograde idea, and we find some delighting in putrid canals and rivers, others admiring the gases from brick-kilns, and others, again, those from accumulations of farmyard manure. The pressure of experience, however, is so strong that these ideas will probably soon vanish. It has often been asked—Will a sewer produce cholera, or plague, or cattle disease? We cannot say so, or that every kind of disease may be produced from such accumulations of organic matter. The great epidemics that have passed over Europe seem always to have come from some extraneous source, to act as if planted by some seed, and not to have risen up spontaneously here. Without attempting to examine this matter carefully, the result here would seem to be, that whilst the decomposition of organized beings after death produces gases and vapours that are opposed to health, these gases or vapours are incapable of originating, although they may be capable of feeding, some of those diseases, such as cholera or plague, which have been observed at all times to come from a warmer climate. There must, however, be some first origin of these diseases, and we cannot prove that the first origin might not take place in our climate, although it seems probable that it requires a warmer sun and a richer vegetation than is to be found in the north. This, however, is sufficiently made out—that, when these diseases do come amongst us, they take root with most effect in those places where decomposing matter is found. If we were to suppose a seed of disease planted in a rich, fertile soil of decomposing matter, we should give a pretty fair description of the fostering effect of impurity on disease. It would in fact appear as if the putrid matter itself took the disease, and transferred it to the living. There seems to be nothing entirely opposed to this view of the case. The question, however, is and has always been—What is the nature of that substance which may be said to form the seed or germ of the disease? Chemists have been inclined to consider it a substance in process of decay, as the quotation from Liebig already given shows. Physiologists and microscopists have been more inclined to consider it as an organized substance. When Gay Lussac passed a bubble of air into the juice of grapes, and found that fermentation began at once, it was believed that the oxygen was the prime mover, and that, when once begun, the action did not cease. When, however, Dusch and Schroeder found that flesh did not decompose if the air was previously passed through a good filter of cotton wool, some difficulty was thrown on the subject. It would appear as if oxygen were not the only agent in the atmosphere causing decomposition. The investigations of M. Pasteur, who found the subject in this uncertain condition, have advanced it so far that we may now with certainty reason in the belief that organized substances are really found in great abundance in the atmosphere, and that they are the cause of some hitherto entirely mysterious phenomena, even putrefaction included. His object was first to inquire into the possibility of spontaneous generation, and he found that carefully filtered air allowed no organisms to appear in vegetable solutions. He found that near the usual surface of the ground these organisms were so numerous that whenever a vessel containing vegetable matter fit for their growth was opened for a very short time they were found to enter, that in cellars and damp and quiet places, where there was no air or dust floating about, these organisms were fewer, and that, as he ascended the sides of the Alps and the Jura, they diminished in number. A commission of the French Academy confirmed his results. If we examine previous inquiries into the compounds resulting from the decomposition of organic substances, we shall find nothing which is at all calculated to bring out such an intelligible rational view of the origin of many diseases, and also of some phases of putrefaction. Chemists, when they have examined products of the latter action, have found sulphuretted hydrogen, carburetted hydrogen, hydrogen, carbonic acid, nitrogen, ammonia, acetic acid, lactic acid, butyric acid, and numerous uncertain bodies having no activity, and utterly incapable of producing those prodigious results that are found when that force begins to work which produces plague, smallpox, or black death.

Sulphuretted hydrogen, itself one of the most deadly of gases, has not been known to produce instantly any disease. It cannot, in fact, be said in any way to be similar to an infection. It may in very small quantities lower the tone of health, and it does so, and it may gradually diminish vitality to such an extent that disease ensues; or, if undiluted, it may kill as suddenly as a cannon shot; but it never can for a moment be compared with the infectious matter of smallpox or of scarlet fever. Chemists much in a laboratory are exposed to it daily; sometimes in considerable quantities, and the result has been as stated. The same may be said more or less of all substances found by chemists as the result of putrefying matter. It is not said that these gases are not unwholesome, for their unwholesomeness is known; but it is extremely important to distinguish them from those hitherto, and still, mysterious substances which convey infection. The question is quite open. Is the cause of disease an organic substance in the process of decomposition conveying that decomposition to another body, or is it an organized germ?

The two great theories may be called Liebig's and Pasteur's; the first, Liebig's, dealing with organic decomposing matter ready to communicate its action by its own activity. That this idea has a sound scientific basis will to a great extent be admitted. I am disposed to think it quite undeniable at present. The second, that of Pasteur's, leads to organized bodies or germs, and although he also has not first originated the idea, the clearest proof and expression is due to him. He does seem to have retained firm hold of a part of the battleground gained from chemistry. There is probably a point where the organic and organized touch so nearly as to be difficult to distinguish; but here the distinction between the two is very real, and the point of contact is still to be sought.

I am afraid of moving out of the sphere of the chemist, and hope I do not go too far when I suppose classes of disease caused—1st, *by gases*, easily diffused into air, and more or less soluble in water; 2d, *by vapours*, heavy and capable of falling, especially in cold air, capable also of being taken up in the moisture of fogs; 3d, *by putrid or decomposing substances;* and 4th, *by organized bodies in various stages and ferments.* Disinfection is the destruction of one or all.

1. *Gases.*—The composition of gases arising from putrid matter does not seem to be uniform, but to depend on several conditions, one of which is the supply of oxygen. Dalton found the marsh gas from the floating island at Derwentwater to contain

Carbonic acid, . . .	6
Pure marsh gas, . . .	47
Nitrogen, . . .	47
	100

No trace of oxygen appeared in it.

Bunsen found the gas from a pond in the Marburg Botanic Gardens to contain, after he had removed the carbonic acid—

Marsh gas, . . .	48·5
Nitrogen, ...	51·5

Had Dalton removed the carbonic acid he would have had 50 nitrogen and 50 carbonic acid. The two analyses closely approach.

In Staffordshire, Howard obtained

Pure marsh gas, . . .	99·6
Carbonic acid, . .	0·3
Nitrogen, ...	0·1
	100·0

Dr. Letheby made many analyses of gases from decomposing sewage, and gives in his report on sewers and sewage gases from 13 to 84 per cent. of marsh gas, and above 3 per cent. of sulphuretted hydrogen in some places.

From the Marburg Botanic Garden the difference in winter and summer is given by Bunsen (*Jahresb.*, vol. iv. p. 849, table) :—

	In summer.	In winter.
Marsh gas, .	76·61	47·37
Carbonic acid, .	5·36	3·10
Nitrogen, . .	18·03	49·39
Oxygen, . .	...	0·17

Analyses of gas from coal pits varies also excessively. Bischof gives the following table :—

	Bischof.			Th. Graham.	
	1.	2.	3.	4.	5.
Marsh gas, .	83·08	91·36	79·10	94·2	82·5
Olefiant gas, .	1·98	6·32	16·11	...	...
Oxygen gas, .	...	...	...	1·3	1·0
Nitrogen, .	14·94	2·32	4·79	4·5	16·5

The specimens here given of gases from marshes or ponds may be supposed to have been formed in a similar way.

The gases which I obtained from putrefying blood were as follow :—

Carbonic acid, . . .	97·09
Sulphuretted hydrogen, . .	1·93
Hydrogen, . . .	0·1804
Carbonic oxide, . . .	0·1396
Carburetted hydrogen, . .	0·0729
Nitrogen, ...	2·5171

The unabsorbed gases of themselves are—

Carbonic oxide, . .	4·8
Marsh gas, . .	2·5
Hydrogen, . .	6·2
Nitrogen, . .	86·5

The amount of these last gases was so small that I am quite willing to suppose some errors in one or two.

The analysis of the gas arising from the sewage matter at the bottom of the Medlock is—

Nitrogen, . . .	5·35
Carbonic acid, . .	5·84
Marsh gas, . . .	88·81

The matter here was extremely putrid, and the water over it putrid also, and therefore free, or nearly so, of oxygen. It is curious that in this case the amount of nitrogen is so small, resembling more the mixture from some of the coal beds. In cases where the water is extremely clear above the turf, at the roots of which the marsh gas forms, as, for example, at the floating island of Derwentwater, the nitrogen is much greater.

These analyses show that the nitrogen diminishes when there is an excess of putrid matter, and increases with an excess of purer water than the mass which is decomposing. The blood was putrefied as free from air as possible. There are two modes of explaining the difference in the amount of marsh gas: 1st, there being less air admitted, the amount of nitrogen was necessarily less if this gas was obtained from the air; but if obtained so, how did the air enter? it may have penetrated into spots from which it had no power of returning without great mechanical efforts; this must have been by an act of diffusion, the oxygen being continually taken up and the nitrogen left alone; 2d, the nitrogen may come from the organic compounds. In this case, we may suppose or not a supply of oxygen. If we suppose no continuous supply of oxygen, we have the carbonic acid formed by the carbon seizing the oxygen of the organic matter, and this no doubt it does in the case of the blood. The amount of carbonic acid which can be formed in this way is easily found. There is, however, the oxygen of the water, and in the case of the blood gas there are no hydrogen compounds to correspond; blood decomposes at a high temperature independently of the external air. The first method seems probable.

At any rate purer ponds give out more nitrogen; impure bubbling filthy matter gives out little. This may be used as an inferior kind of test of the state of waters.

Besides these gases, and others, known and unknown, which have been examined, there is a fœtid matter, and also a substance containing nitrogen and carbon, and evidently of an organic origin. This substance was obtained by an alkali. When the putrid gas has passed through cotton wool, a substance is retained of an excessively disagreeable smell, more so than any other portion in liquid or in gas. We are not certain that the substance could not communicate its putrid state to other bodies without the intervention of organisms, although we quite know that the larger results of putrefaction, namely, the gases mentioned, are quite incapable of this communication. If, however, the communication to bodies at a distance takes place by means of a chemical substance, that substance must have some definite shape and size. If it were a mere gas, it would instantly expand on coming in contact with the air, and become so divided as to cease to have any influence. If it were a vapour, such as water, or any of the acids or fats which pass off along with the gases, the same infinite attenuation would take place when mixed with the air, and this extremely fine division would, so far as we know, entirely prevent any action. In other words, the power would be diminished in exact proportion to the amount of air with which the gas was diluted. In order that a substance should act like yeast, it must at least have parts to decompose; but in the state of division attained by gases mixing with great volumes of air, the limit of size seems so nearly approached that the idea of parts separating, and so communicating their habit of separation in this state of division, is against our conception, which rather represents them as having arrived at atomic division, or at least that of the undivided molecule. But if we examine the action of sulphuric acid, water, and zinc, we find that the particles of acid and water which are lifted into the air by the effervescence, float about the apartment, and are carried to a considerable distance. They are globular bodies visible to the naked eye, purely chemical, and not organized substances. We might suppose bodies to arise from putrid matter in a similar way, and by this means we can picture to ourselves the conveyance of substances in a state of decomposition, planted, as germs would be, upon fresh matter ready to yield to its attacks, but not germs in any true sense of the word. We can imagine that even one of these particles could be carried over an immense district of ground, and deposit itself on some spot, favourable or otherwise to its action. This at present is a fair subject of inquiry; we cannot say whether it really takes place or not, but it is hard to think otherwise. Such substances like particles of floating pus are retained by wool. Lemaire considers that putrefaction cannot take place without germs.

2. *The vapours which we find among evening dews on marshy places.*—These are evidently not gases. They do not act as if they retained organized germs. They are bodies volatile at warm temperatures, cooling and contracting at the same temperature that we consider cool, and thus becoming concentrated. Boussingault and others have found a good deal of organic matter in air of marshy places. Many generations of men have died in doing the work which has made our land healthy.

3. *Putrid vapours.*—These are apparently different from the others. They are accompanied by the gases spoken of under No. 1, but they evidently contain very powerful and hurtful organic substances. They may also contain organized substances. Dr. Dundas Thomson obtained many organized forms

in the sewer air, and still more in wards of hospitals; but these evidently do not constitute all the unwholesome particles of the exhalations. They are mixed volatile organic substances, with different properties from those arising from marshes.

Their mode of action and transference may be supposed the same as alluded to on p. 27.

4. *Germs of disease* are fed by organic matter. Dead matter probably feeds them at once, but they contrive to feed on living matter when they are strong or numerous enough. Such, at least, seems to be the true explanation of many of the phenomena observed. The germs may be tossed about, but their diffusion in the chemical sense into the atmosphere is impossible; they have a distinct, definite size; must be carried forward by the atmosphere, and will occasionally deposit themselves. If they float about very much in the atmosphere, both they and the chemical substances mentioned will become dried up. In that case activity might be destroyed, but less so in the case of the germ. If the germ were deposited in a place where there was abundant matter in which it could grow, to produce either a further advance of itself, or multiples of itself, it is easy to imagine that that place would become infected. If the germ fell upon a spot in which there was none of this matter capable of reproducing it, the germ would cease to be a conveyer of infection; and so we can explain to ourselves why one place becomes capable of fostering disease and another not. This view does, in fact, seem to explain many of the apparent vagaries, if we may so speak, of cholera and of plague. These diseases start up strangely, often in places where they would be least expected. Germs may be conveyed as the wind or other agents may choose to move, and houses where persons are in all respects cleanly in their habits, may be occasionally objects of their attack. But this does not contradict the great rule which

seems everywhere observed, that they should settle down in places where is found such natural food as animal and especially decomposing animal and vegetable matter and close dwellings always provide, unless when the germs grow better in living animals.

These explanations may be called two, the chemical and the germ theory (Liebig's and Pasteur's). They are not mere fancies. We extend only the known to the less known and the unknown. The two causes give two results not contradictory.

There seems no reason to limit the number of infectious diseases, till the number of chemical substances transferring decomposition is limited also, and until the number of germs, and the list of their transformations, is finally completed and made known to us.

ACTION OF DISINFECTANTS.

Animal matter, which chiefly is found to be dangerous, is, in fact, the fæces or *dejecta* of human beings and of cattle. It might be supposed that these substances had already been decomposed; but such is not the case. The decomposition is very imperfect, and when they are allowed to stand, putrefaction sets in, closely allied to, perhaps exactly the same, as that which takes place in other animal matters, such as blood, or in a mixture of flesh and water. When these substances decompose, the result is, so far as we know, nearly the same as the decomposition of the entire animal body. We are not able to tell the difference between the products of putrefaction from our cesspools and those from our graveyards. The problem, then, of preserving meat, or of preserving the entire animal from corruption, and the problem of preserving sewage and fæces from decomposition, become entirely one and the same. We are required to do for the fæces that which the

Egyptians did for their dead bodies, until they shall be thrown upon the ground, and mixed with the soil and become the food of plants. As instances of the action of antiseptics, see the results of various modes of treatment of the dead. When, however, antiseptics have been used, the whole seems to be preserved. Some substances, like the metallic salts and mineral acids, generally combine with the flesh or with portions of it, and by making a permanent compound prevent the action of air. Some substances, such as charcoal, condense the oxygen within their pores, and assist the destruction of the animal matter. Others, like permanganate of potash, give out the oxygen, which they contain in large quantities, and thus hasten the formation of carbonic acid. Some of them, like chloride of lime, give out oxygen and other gases; and some of them, like sulphurous acid, act by taking oxygen from the substance to be disinfected, so that there is a surprising variety in the modes of action. Of these substances, however, we might say there are two classes: those which act upon the solids and liquids, and those which are volatile and act upon the air. Let us suppose one, either of the particles or germs of which we spoke, to come into a stable and fall upon some material ready to supply it with food, it will grow; but suppose that material to have been treated with a chemical substance, say chloride of lime, the germ would itself be poisoned and growth would cease. Let us suppose, however, that same germ, instead of lying upon a disinfected substance, to have entered into the lungs of the animal. The question may be, Can it be taken up into the vital system? We know that when some germs enter into the corner even of a large vessel containing blood, putrefaction goes on from beginning to end. We can readily imagine a similar result in an animal, for, although the effect may not be properly called putrefaction, still it is a disease somewhat analogous in its nature. The disinfection of the manure, or of the cow-house or stable, in such a case, would have no effect upon the animal, if the disinfectant itself were not volatile, except in a secondary manner, by preventing the atmosphere from being filled with the volatile substances from the manure. The use of such solid disinfectants would therefore be valuable, but limited. If, however, the disinfectant were capable of acting first upon the solid manure and liquid itself, and then, rising up into the atmosphere, pervading every corner of the apartment, the result we might expect to be very much more important. When also this disinfectant continually entered into the lungs, mouth, or skin along with the atmosphere, we might look to that as a still further precaution.

In the use of disinfectants it is necessary to distinguish between those which may be used for occasional purposes and during great epidemics, and those which may be constantly used. It will be important for the farmer to use those which have a beneficial effect upon his manure, and which retain all its fertilizing properties, and, besides, it is necessary that they should be agreeable to the cattle, and that they should be agreeable also to the senses of those who are going about.

COMMON PRACTICE OF DISINFECTION.

The art of disinfection is so little practised, and the theory so little developed, that we can scarcely fix upon any generally recognised modes of procedure. Perhaps, of all substances, that most used in England and best known is chloride of lime; and certainly it is a very powerful agent. In France, chloride of potash (soda), *Eau de Javelle,* is most used in private houses, and chloride of zinc for the disinfection of cesspools. The latter is otherwise called (Sir William) Burnet's Disinfecting Fluid. In Germany, I believe, salts of iron are more used when anything is used. With us, chloride of lime is sometimes used at railway stations, and sometimes in private houses, when the public becomes alarmed. For houses, Condy's liquid. For stables, cowhouses, and middens, no disinfectant is used as a rule, although some have for many years employed in such cases M'Dougall's Disinfecting Powder. (Others now make similar compounds: this was written in 1866.) Earth, charcoal, and sulphate of lime have all been employed in such cases, but perhaps of these charcoal is the only one which has been used to a great extent, and that chiefly for the ventilation of sewers, and the purification of air passing into the lungs through a respirator. This use has arisen from the investigations of Dr. Stenhouse, who first showed the power which charcoal exercised in compelling the oxidation, as it were, of organic vapours and gases, which were known to be greatly absorbed into its pores. Chloride of manganese and chloride of iron have both been proposed as disinfectants for sewage; but I am not at all aware that they have ever been used to any great extent, although their power of disinfecting is known to be great. Soot, ashes, charcoal, animal charcoal, and peat charcoal have all been proposed, and some of them are used, according to convenience. There seem, in fact, to be few substances in nature incapable of acting partially as disinfectants, the putrid matters themselves excepted.

GASES AND VAPOURS.

Oxygen.—Few except chemists comprehend the meaning or chief characteristics of oxygen; its character ought to be more generally known. Twenty-one per cent. of the volume of the air is oxygen. It is an active agent, attacking nearly all substances which it has not already attacked to its satisfaction,—metals and organic substances. When a metal resists it, we call it noble. When it attacks metals or organic substances rapidly, it produces heat, forming gases, or leaving ashes and dust; when it attacks lifeless bodies, it produces decay; when it attacks living animals at the usual temperature, it produces life and moderate instead of violent heat.

By defending substances from the attacks of oxygen we preserve them from those changes which are well known to occur in the air. Oxygen is always attacking us, but the processes of life defend us; there is an attack at every inspiration, and a repulse follows at every expiration,—by the conflict we obtain warmth and vitality. To cause it to cease would be to cause death. When we desire to preserve substances from decay, we avoid all the attacks of oxygen, and seek to keep down all change.

Oxygen attacks organic matter by numberless plans, and we may even say subterfuges. It clings to all surfaces, and accumulates in bodies reduced to powder where the surface is enlarged. This is true especially of metals and charcoal, but it is also true of soil, sand, etc.

Every substance in fine powder disinfects,—dust of all kinds, whether platinum powder, or powder of sandstone. The surface is enormously increased in such bodies, and surfaces attract the air which is confined and pressed into service, causing more active oxidation and therefore more purification. When all the oxygen is expended, this process ceases, so that the soil retains the evil, and gives it out when stirred. But let us send a volume of oxygen down, and the state changes. This operation is effected by nature when rain is poured over the soil and when it sinks down with its dissolved air, beginning an action so extensive that by it we may say nearly all the purification of the world is performed. If, however, the rain falls and remains, it soon also becomes exhausted of its oxygen, and the purification again ceases, whilst the vapour rising takes with it some of the injurious air. More water must flow, but it cannot do so until the previous amount is removed, and thus we see the necessity of drainage. It is a constant flow of air and water purifying and making carbonic acid for the food of plants, to enable them to convert that again in part into oxygen, for animals to breathe, and food for the same to eat. Here we see the value of flowing and the evil of stagnant water, the value of drainage and of deep-soil ploughing. If this be the case, the advantage of drainage consists more in the flow than in the removal of the water. If the flow is sufficient, we have not malaria, marsh-fevers, agues, etc. If the plants are not decomposing we are also free, and thus we find that in cold, malaria is diminished or stopped, because cold prevents decomposition, and water of peat-bogs gives out no injurious gases, for the peat does not putrefy.

So powerful is this action of oxygen that even when all the organic matter is decomposed, this remarkable gas continues to accumulate when it can find entrance, and heaps itself up around certain bodies, forming nitric acid—a reservoir of air for the use of any more vegetable matter which may arrive. It is thus that near the most impure places, if the water passing through them is detained long on the road, the organic matter is removed thoroughly, and the nitric acid formed is sufficient to give it a strong taste. It is nature making violent exertion to bring a supply of oxygen where it is most wanted. Strange to say, this accumulation is made by nitrogen, the very substance which is found characteristic of bodies capable of putrefaction. This nitric acid is united with lime, magnesia, or potash, and with the latter makes saltpetre.

In times gone by our floors were the earth only, as in many cottages now, and we used the broom or brush little, and threw the garbage down, allowing it to lie and rot and become so vile that we invented the device of covering it over with straw, so that it might be trodden down, as the cattle make the manure in the straw-yards. The earth of the floor was overloaded with putrid matter, and much of it came into the air of the room, but the formation of nitre or saltpetre began, and oxygen accumulated rapidly, and rendered even these houses habitable in a way.

The Government soon found out this growth of saltpetre, and sent "Petremen" to obtain it by force. They entered houses without pity, and seemed to increase the discomfort of a household to the utmost, that they might be bribed to leave. It is not for this volume to describe the tyranny of these wretches, but their doings illustrate, much more even than the more distant miseries of war did, Shakespeare's words, "villanous saltpetre." "The harmless earth," out of which it was dug, may mean rather the earth in the house of a harmless family, where perhaps some tender life was lying in danger, whilst these men insisted on removing the bed, and rendering the whole apartment wretched.

It was fortunate when the search for saltpetre, like war itself, went abroad. Now we find that great collections of oxygen have been made by a similar process in early ages, and are lying ready for our use, just as collections of coal and firewood have been made for a population too large to grow enough for itself, or too wanting in foresight to plant as rapidly as it destroys. These stores of saltpetre from India and South America are used for oxidizing. They are concentrated air, which burns charcoal so rapidly as to make an explosion, and which purifies exactly as air purifies.

We have not been able to use this power hitherto for household disinfection in bad cases, it is almost too powerful, but we use it as an antiseptic for preserving meat, when saltpetre is added; nitrous gas from it has been used for fumigation; its oxygen has also a powerful action, especially as nitric acid, in restraining putrefaction, although the mode of using it in this form is not yet made quite clear.

There are, however, other bodies which condense oxygen, and one which we get from Norway, Shetland, etc., brings us chromic acid, used for chromate of potash, remarkable agents in antisepting. We must coin the word to *antisept;* we have none that can take its place.

But even chromic acid has not become familiar; it requires attention, and we must look to other oxidizers. We have chloric acid, a body with still more oxygen, and most powerful, and its compound, chlorate of potash, which may also be used. All these bodies give out oxygen, and are therefore oxidizers, purifiers, and disinfectants, although less properly antiseptics. But they are not enough, because practice has not taught us the best modes of applying the peculiar characteristics of each. Manganese condenses oxygen, forming permanganate of potash, a substance beautiful in colour and innocent in character, whilst it oxidizes powerfully all the foulest bodies, and removes the most putrid odours as if by magic. We have to thank Mr. Condy for teaching us its use. It is certainly an elegant disinfectant, a name which it bears in opposition to antiseptic, which it is not, as it does not preserve. This permanganate, sometimes called chameleon, may be put into the foulest water or the most repelling mixtures, and the sense of smell will cease to be offended, whilst we may be sure also that soluble injurious bodies which do not smell will be equally oxidized. It leaves potash and oxide of manganese. It would be well if we could get the permanganic acid without the potash, and when it had done its work it would quietly fall to the bottom of the vessel, and if we were using it to purify drinking-water, we should have only a little brown oxide, which would do no harm, or if it had an unpleasant appearance, we might let it sink and leave the liquid above perfectly pure.

The most practical and well-known form of applying condensed oxygen is found in the permanganate (Condy's Fluid). It is poured on the offending substance, and when offence begins again, more of the fluid is used. In sick rooms and other places there are frequent occasions when it is really impossible to carry away the impurity with sufficient speed, or entirely to avoid its presence. Condy's solution has no smell, and is pleasant to look at.

In a table to be given, it will be seen that chromates keep substances long from corruption, although containing less oxygen than permanganate, and it is also found that nitric acid has this power. The writer of this is aware that having observed such things he ought to have followed them up so that the public might be able to know their use, but the preliminary experiments alone were made. They promise success, and those who can give time would do well to do so. As a rule oxides are disinfectants—that is, removers of smell, deodorizers, and destroyers of decaying matter, but not preservers of substances or antiseptics.

PEROXIDE OF HYDROGEN.

There is a disinfectant with scarceness for its only fault; that is, pure oxide of water, or peroxide of hydrogen. It looks like water; if we pour it on the filthiest substance the smell of putrefaction ceases, and in many cases a sweet odour or fragrant perfume, created in an instant, arises in its place. The peroxide has given up its oxygen and pure water only remains, no remnant to which we can object. Is there anything beyond this? Scarcely, although it does not seem applicable to all waters. It is dear, unfortunately, but some day it may be cheaper. Here also work is needful, and although we know these remarkable qualities we do not know details, and cannot yet tell how far it can be generally used; every substance has a character as complicated as the relations to all other substances and conditions of substances can make it.

This is the substance to which we must turn; it promises to be the disinfectant of the future, not to be surpassed. As we obtain it, it is not strong enough for all cases, so at present it cannot be recommended for practice. If water could be compelled to take up perhaps 100 volumes of oxygen in combination, probably no impurity could resist this.

Some people deliver over all their wonders to electricity, and imagine that by doing so the mystery is solved, instead of being increased, by the idea that such a power is doing everything. But in the atmosphere we have really an abundant action of electricity, as we well know, and we are able to detect some of the concentrated or allotropic oxygen which it forms; whether it should be called ozone, or peroxide of hydrogen, or other oxide, is not of consequence now. Very likely all the names are correct, and even more. When rain falls it brings this oxygen with it, and so we find at last that we have our ground watered, not with water only, but with this purifying agent. We can trace this more vital part of the air in all places where it is exhilarating to breathe, but never in a crowded town, never near much smoke. The very rain of such latter places differs from pure rain, and it falls on ground without the full power of oxidizing and preparing food for the plant. From towns it is tainted with sulphur from the coals, and this helps, with tar and soot and ammoniacal salts, and coal-dust or ashes, to render the air unwholesome. But without forgetting this long list of evils in the smoke, we must remember the loss of concentrated oxygen, which can never enter our smoky towns for a moment. It is that oxygen mainly which makes pure air so wholesome when it sweeps through a house; it burns up everything that is disagreeable to the sense of smell as certainly as a fire, although with more discrimination.

Although knowing the wonderful position oxygen takes as a purifier in nature, we use it very little directly; we leave its work to nature. Permanganate is the form in which we can best use it. We want a few more oxidizers. There are numerous bodies ready to oxidize, manganese and iron freshly precipitated, ready to give and then to take, and so act as carriers, and these nitrates and chromates require attention. But the world seeks exact knowledge; we shall endeavour to distinguish here some of the known from the uncertain.

We have spent a good deal of time on oxygen, and we could spend much more; it is Nature's great purifier, called once by Priestley "vital air." It is our greatest and best agent of purification, although, as yet, it has been too noble to allow itself to be used in the daily work of life in disinfection so fully as we require; as the dignity of labour increases, this gas, no doubt, will yield to the persuasions of mankind, and take more part in our artificial life.

Perhaps it may be said that in the above there is a little contradiction. Oxygen is said to cause decay, and then it is said to cause purification. It is so; a little oxygen produces deleterious compounds, a great deal is a sure purifier. We must learn the mode of applying the properties of the higher oxides, bodies which contain concentrated oxygen, and are equal to enormous volumes of air in a small space.

SULPHUR.

Nature had the first claim, and as it begins with oxygen it was our duty to do so also, but had we followed history we should have begun with sulphur, a substance called sacred or divine by the Greeks, and used in purifications. It must have been ready at hand to Ulysses, when, after killing the suitors, he fumigated the palace, not to remove the odour of the dead merely, but as a religious ceremony[1] (Homer's *Odyssey*, Book xxii. line 492). Cowper translates the passage thus:—

> "Bright blast-averting sulphur. Nurse, bring fire
> That I may fumigate my walls; then bid
> Penelope with her attendants down,
> And summon all the women of her train.
> But Euryclea thus, his nurse, replied:
> My son, thou hast well said, yet first I will
> Serve thee with vest and mantle. Stand not here
> In thy own palace, clothed with tatters foul

[1] *Memoirs of Literary and Philosophical Society of Manchester*, vol. xii.

And beggarly ; she will abhor the sight.
Then answer thus Ulysses wise returned :
Not so ; bring fire for fumigation first :
He said. Nor Euryclea his loved nurse
Longer delayed, but sulphur brought, and fire,
When he with purifying steams himself,
Visited every part, the banquet-room,
The vestibule, the court."

And afterwards, near the beginning of Book xxiii., Pope writes Euryclea's words—

" Glorious in gore !—now with sulphureous fires
The dome he purges, now the flame aspires."

The shepherds purified their sheep with sulphur as well as bleached their wool, and in Ovid's *Fasti* we have (Book iv. lines 739, 740), " Let blue smoke arise from the burning sulphur, and let the sheep bleat when touched by the smoking sulphur." The Italians may perhaps have it by tradition as a mode of purifying their vines and their wine-casks, for which, indeed, it is used over all the wine-growing shores of the Mediterranean, to such an extent, that a new Etna neighbourhood would be a commercial advantage, if the Greeks do not now use, except on a small scale, the volcanic island of Melos for sulphur. Brimstone, sulphur sublimed perhaps, was used for skin diseases and in poultices of old, and the smell of it is spoken of by Pliny as accompanying lightning. Schoenbein first told us that the smell was in reality that of ozone.

Sulphurous acid, which is obtained by burning sulphur, arrests the action of organized bodies, whether it be that smaller movement of decaying meat, or the more noble one of living man. It first deoxidizes, but it gives off its oxygen easily, and acts as an oxidizer. It also acts as an acid, and dissolves animal matter. Its action is complex. It causes coughing, and it is in great quantities injurious to the lungs, but how much in small quantities is not well known. It purifies the air from putrid matter, destroying that when in a state of vapour, as it destroys putrid and living bodies dissolved or in a liquid state, and it is therefore an excellent fumigator. How much it brings of other evils is an important question. It alters the air of our towns entirely; every coal-burning town certainly is compelled to breathe it. In vitriol-works men lose their teeth, but seem after a while to become accustomed to the sulphur. How far the burning of sulphurous coal is one of the causes of the great decay of teeth, is a question which statistics of country and town teeth may answer. It is offensive in very small quantities, as is shown when gas burns with a little sulphur in it. Even a few grains burnt in the gas and continued during an entire evening are enough to annoy us, although the same amount rapidly burnt, and breathed only a few minutes, is less hurtful. True, all the discomfort arising from gas is not due to sulphur, as it has been proved that with incomplete combustion acytelene, a compound of hydrogen and carbon, is one of these unburnt gases given out.

As a fumigating disinfectant sulphur must hold a very high place, but there is a difficulty in most cases of keeping up the supply. It burns and goes out readily. We desire to keep it constantly burning. This cannot be well done in small quantities; it would for small spaces be best to use a sulphite of soda or lime, and add a little weak muriatic acid to it; in this way the supply for fumigation might be kept up.

When the gas combines with any body, it forms a sulphite. Sulphite of soda, lime, etc., are disinfectants. They act by removing smells, not all, most decidedly, but some. The most putrid blood will become comparatively innocent when sulphites are added, but a smell remains, a concentration of that which we find in a fresh slaughter-house. The worst part, perhaps all the dangerous part, is removed. The action goes on, and oxygen is given up, until at last sulphuretted hydrogen escapes, the very substance that sulphurous acid so easily destroys. We must therefore lift the whole away before that action sets in. Schoenbein says that this acid oxidizes, and so causes an oxidating influence on other bodies to set in. This is sufficiently explained by the fact of its parting with its own oxygen. Mr. Jas. Higgin of Manchester used for many months sulphite of soda for his cattle during the plague of 1865 and 1866, daily about two ounces. They have not suffered, although all around have done so. One or two others have done the same with a similar result. Mr. Crookes tried injection into the jugular veins of diseased cattle of half-an-ounce dissolved in three ounces of water. They were better for a while, but ultimately died.

The salts of sulphurous acid are active disinfectants till they lose so much oxygen as to give off sulphur, and this occurs when much liquid is present. Some persons have observed the cattle which were dosed daily with about two ounces of sulphite of soda to become much weaker. This has not always been the result. When the substances have not begun to putrefy, sulphurous acid acts as an antiseptic.

One of the most remarkable applications of sulphurous acid is in preserving meat, the newest being that of Mr. Gamgee's, by killing the animal with carbonic oxide gas, and keeping the meat in that gas and sulphurous acid. This is said to keep the meat fresh for six weeks, and of the original colour. Previously the air was pumped out, and the sulphurous acid allowed to enter.

The use of sulphurous acid as a liquid has been tried. The sulphides have been patented by J. Young, F.R.S.E., for removing the oxygen from air so as to prevent putrefaction.

This account of sulphur although short comprehends a great many careful investigations. In modern times we have so much to deal with that we put the labours of lives into a few words, and scarcely have time to value them. In writing on all the disinfectants it is needful that each should have its full merits shown. Some persons take one only, and show that all things can be done by its means. It is difficult to say who is right. We find that by a law of nature we obtain various sounds by the use of various strings, but one man comes and equally by using nature's law brings various sounds from one string. Surely we shall not ask which way is right, but it is well enough known that the use of several is an easier mode of attaining the end.

These remarks are suggested by a publication on the application of sulphurous acid, by Dr. Dewar of Kirkcaldy, and by another much longer, recommending the first, and actually going out in its 13th edition (by Robert Pairman, surgeon, Biggar). Dr Dewar goes forward with such clearness, simplicity, and joyous confidence, that we may well feel ashamed of any further elaboration. He says—

" It may be well to premise that our adoption of such an auxiliary implies a belief that the enemy of which we are in pursuit lurks about indefinitely; that its vitality can outlive ordinary processes of decay; and that it is transmitted by, or at least is located in the atmosphere. This being the case, we may as well assume that the germs are of parasitic, most of them of vegetable origin; that some retain their peculiar properties independent of temperature or climate; and that some even can (as in cholera) in a dry climate, in the form of dust, be carried by the wind to distant points, where, as they absorb moisture, they regain their power of spreading devastation." He uses for cattle disease " a chaffer two-thirds full of red cinders, a crucible inserted therein and a piece of sulphur." He treated his own cattle to this four times a day, the sulphur for six cattle being about as large as a man's thumb, and burning for twenty minutes, the attendant being shut in along with the cattle. The cases of cure are said to be numerous; a horse treated accidentally was cured of grease in the heels, and many cases of cattle plague being averted from previously unhealthy houses are mentioned. He extends the use of sulphur and the theory of parasites to phthisis, diphtheria, and other diseases, as well as to the purification of sewers and the preservation of hides, but especially to epidemic diseases. He goes far. There are evidently points in which he is right. It is not to be doubted that sulphurous acid, the fumes obtained by burning sulphur, disinfect well; it is, however, not well to breathe even small quantities long —such at least is my opinion. It must be taken as a medicine. The constant presence of even small quantities diminishes the oxidizing power of the air, although the occasional application of large quantities may be valuable in destroying the noxious substances collected in it. However, the medical question must be avoided here.

No one has gone beyond Glauber, in 1689 Ed., Part iii. p. 2 :—" Whoever shall attempt to describe sulphur in a most accurate manner (as is fit, although not expedient) will have need of abundance of paper. But he that knows nothing of *Sulphur*, knows nothing at all, nor is it convenient he should say anything, either in medicine or in philosophy, touching any of the secrets of nature."

The chief use of sulphurous acid seems to be obtained from it in the state of gas. It is easy to raise vapour sufficient, but it must be remembered that it destroys vegetable colours to a great extent, and acts on metals and on alkalies and alkaline earth such as lime; that it is absorbed by porous substances, such as cloth, leather, and even wood. In some places these qualities are not hurtful, and in others the disinfection is so important that it must be performed at the risk of causing many minor evils.

The old Ulysses plan of burniug sulphur remains to this day excellent, and the use of it for wool also. It is an old plan, I am told, to use a piece of new flaunel for wounds; it has been suggested to me that the sulphur remaining in it from the time it was bleached by that substance being burnt near it may be the cause of the cure. Dr. Dewar says it has been loug common in Scotland to seek employment for delicate persons in wool mills where sulphur was used for bleaching. The joke on this subject against Scotland must be allowed, it is not new.

Mr. Crookes,[1] F.R.S., says,—"A mixture of sugar and yeast was kept in a warm room until it became in a state of active fermentation. An aqueous solution of sulphurous acid was added, when the fermeutation instantly ceased; when examined under the microscope after treatment with sulphurous acid, no apparent change was observed in the appearauce of the cells."

In French hospitals sulphurous acid is used for fumigation in skin diseases, the body and clothes being fumigated, leaving only the head out. It is used for washing beer barrels, to prevent mould, also for wine and sugar casks, as well as vessels to contain flesh or other food.

Evils of Sulphurous Acid.—This acid gas is an irritant and causes violent coughing, which becomes painful and dangerous according to the amount used. It is very destructive to vegetable life. Animal life resists it better. If any disease is caused by a germ analogous to a plant, or itself a plant, this germ will be destroyed, and the object is to give as much as will destroy the vegetable or germ life, and keep sound the animal life. As sulphurous acid is destructive to animal

[1] *On the Application of Disinfectants.*

structures, it does not seem advisable to use it more than can be avoided.

It deodorizes putrid matter whilst it disinfects, but if much is used in a liquid or moist substance containing organic matter it is decomposed, and sulphuretted hydrogen is given out, which can be destroyed by still more sulphur fumes. As a rule, whenever fumigation is used, washing and rubbing ought to follow, removing all traces both of the evil and the cure.

CHLORINE.

Chlorine is a great disinfectant, probably the most powerful agent for the destruction of organic structure, whether healthy or unhealthy. The latter is always most easily destroyed, as it is weak, and putrefying matter still more so, as it is already breaking up; and herein lies our protection: we may use just enough to destroy the decaying but not to injure that which is entire. In passing through bleachworks, we may often have occasion to remark the ruddy healthy faces of the men employed. This is no doubt due to the slight and constant smell of chlorine. This effect is seen at large paper-works where they bleach rags; but nature is always presenting us with new problems. If we pass to the rag department, where the vilest portions of the filthiest clothes of Europe are assorted, and before chlorine is used, we meet persons, at least in cases known, more wonderful in bulk and in every symptom of healthy glow of life, than perhaps in any other works can be found. Perhaps butchers and brewers come nearest to them. The rags have long since undergone their putrefaction, and a something remains, perhaps animal matter, which has this wonderful effect. Statistics do not inform us if such people live longer. Perhaps, as with brewers, there is something dangerous in their prosperity.

(From De Neufville's Frankfurt tables, we do not find that either brewers or butchers had the highest term of life. Our own tables do not place brewers in a high scale, and they give workers in chemical works a higher age, but the numbers are perhaps questionable.) However this may be, the destructive power of chlorine is great. This gas was discovered by Scheele in 1774. We cannot go to the ancients for its history, but we may nevertheless believe that the ancient Egyptians used it, consciously or otherwise, as they evidently obtained nitric acid from their saltpetre, and this, one may suppose, must have in their experiments been mixed with common salt, thus giving nitrous gases and chlorine. In a Danish receipt, not much after the time of the discovery of this gas, acid fumigation is recommended, the fumes to be obtained by pouring sulphuric or nitric acid on common salt. The first gives muriatic acid only, the second chlorine as stated.

Chlorine decomposes readily salts of ammonia, thus destroying manures, and this power is peculiarly shown by chloride of lime, and other of its alkaline compounds. At the same time a peculiarly pungent gas is given off. It cannot, therefore, be well to use it much with manures. When it unites with lime it forms ultimately chloride of calcium, a very deliquescent body. It ought never, therefore, to be mixed with lime-wash.

It is made by pouring muriatic acid on peroxide of manganese. It is also made to flow very quietly by adding one and a quarter of alum cake or sulphate of aluminum, or potash alum, to one of chloride of lime; also, as Mr. Stone recommends, by dropping occasionally a crystal of chlorate of potash into muriatic acid. When vile smells are to be destroyed nothing is superior to chlorine. The action is double: the chlorine combines with hydrogen and thus forms new compounds, with water it renders oxygen nascent, so that it is a powerful oxidizing agent, and so oxygen, with which we at first began, again comes forward.

In fumigating with chlorine we find the senses to be the best judges; for long use there ought to be in the air enough gas to give a very faint smell at most. As a preventive in common cases, it is enough if the smell is so slight that it is perceived only after coming from the open air. Nothing destroys liquid and solid putrid matter more rapidly than chloride of lime.

Liebig in his lectures said, that the frequent use of chlorine in the hospitals in Paris produced lung diseases. The gas is most destructive to animal matter, and is more potent than sulphur fumes. It acts purely by destruction; it therefore deodorizes, but does not preserve. It expends its power and then ceases. Chlorine will thoroughly destroy animal matter, making of the muscle a clear solution, from which, however, the nitrogen is removed. Its rapidity of action in dangerous evils is best obtained by using chloride of lime, soda, or potash (*Eau de Javelle* or *Javel*), applied to the decomposing substances. It may be used dissolved in water. If very strong it will spend its energy on innocent as well as guilty substances, but if used weak, it will attack the decomposing first. It destroys offensive putrid smells as if by magic. With chloride of lime in our hands these need not remain a second. A musty smell is generally removed by a solution of 1 to 1000 of water. It will seldom be needful to use more than one ounce to a gallon, or 1 to 100 by weight.

Evils.—Danger of Excess in Fumigation.—If persons are present the smell must be very slight. The same if the inferior animals are present. Destruction instead of preservation of manures. A slightly unpleasant smell afterwards. Strong fumigation may be used, but no one must breathe the fumes. When strong, very dangerous.

IODINE AND BROMINE.

It will be seeu that these substauces are strong disinfectants like chloriue. Bromine, on accouut of its smell, is not likely to be used, but iodine is not unplcasant, and is more convenient. Mr. Crookes tried it by simply throwing a little, wrapt loosely in paper, on the top of a bookcase. It gradually evaporated. It promises well for private houses, but I know of nothing definite concerning it, except the experiment given under the head of strong gases aud volatile substances.

CARBONIC OXIDE.

This is a most deadly gas, but the account given of Mr. Gamgee's mode of destroying animals and preserving their flesh places it among disinfectants, as it is said to unite with the blood, and aid in preventing decomposition. The same action extended would enable it to prevent that decomposition which is essential to life. It is very poisonous when breathed, being the chief ageut in charcoal fumes.

MURIATIC ACID.

Guyton Morveau in 1773 recommended muriatic acid as a disinfectant. This may be called the beginning of acid fumigation, leaving out the ancient use of vinegar, and the pretty well-known action of acids. The muriatic acid was made simply by pouring sulphuric acid on common salt. It is powerful, and the proposer has written an octavo volume on it of much interest; but even he gave preference to chlorine, which Fourcroy introduced as a fumigating agent in 1791.[1]

Evils.—Irritating to the lungs. Destructive of vegetation —not a good practical antiseptic.

NITROUS FUMES.

Guyton Morveau had no good occasion to be much aggrieved when Dr. Carmichael Smith used nitrous acid at Winchester in 1780, but more perhaps with the reward of five thousand pounds from the English Parliament in 1802.

Nitrous fumes are powerful disinfectants, but can never be used without great danger where there are living beings. We have heard lately of three deaths by exposure to these gases, even when they did not act powerfully on the senses. They are destructive, like chlorine in all bad cases, but there do not appear to be cases where they are to be preferred. The safest use of nitric acid is in the form of nitrate of potash, where we know it preserves, or in the mode which received the recommendation of the Academy of Dijon in 1767. We suppose that when they used it in ventilation the saltpetre was heated, in which case it would give off oxygen gas, which at first is very pure; afterwards nitrogen comes off, and the salt itself, or at least the base, is carried into the air, causing a very stifling sensation. The oxygen, however, would be valuable, and this plan might receive more attention. It is remarkable as having been tried before the discovery of oxygen, which was in 1774. When we can keep up a constant stream of pure oxygen, active or less so, by a self-acting process, we shall gain some new results, but we scarcely can say that such an atmosphere would be wholesome. When

[1] See also p. 15.

workmen enter the sulphuric acid chambers in which nitrous fumes linger they do not appear to feel much annoyed, but in a few hours the effect begins, and death is rapid. The structure of the lung seems to be penetrated by the acid, which gradually dissolves or disintegrates it.

Evils.—The great evil of this is, that the senses do not appear to be affected in proportion to the danger. It is like an invisible enemy, against which we cannot fight.

VINEGAR.

This acid is an agreeable fumigant. It is not so powerful as the mineral acids described, but it may be used longer and more pleasantly: perhaps by length of time an abundant efficacy might be obtained in some cases,—not in all. It was used in the middle ages for plague; the whole person was washed with it. Pliny[1] says it dispels nausea and hiccup, used as a gargle; used also for leprous sores, scorbutic eruptions, ulcers, wounds inflicted by dogs, scorpions, scolopendræ and shrew mice, as well as the itching caused by stinging animals; for arresting hæmorrhage and curing coughs, as well as many other wonderful things.

It is an antiseptic, and is used for preserving vegetable and animal substances, chiefly the former. We are not sure that it can be trusted in very dangerous cases. The pyroligneous acid is the most active, as it contains some creasote. Tainted meat is rapidly made to have a wholesome smell by vinegar, especially wood or pyroligneous acid. This property may be practically used when the meat is not too far gone. Plants and infusoria live in weak solutions, and these therefore cannot be expected to stop the more violent attacks on animal life made by means of germs.

[1] Bohn's edition, translated by Bostock and Riley.

"The repute of this preparation as a prophylactic in contagious fevers is said to have arisen from the confession of four thieves, who during the plague of Marseilles plundered the dead bodies with perfect security, and upon being arrested, stated, on condition of their lives being spared, that the use of aromatic vinegar had preserved them from the influence of contagion. It is on this account sometimes called, "Le Vinaigre des quatre Voleurs." It was, however, long used before the plague of Marseilles, for it was the constant custom of Cardinal Wolsey to carry in his hand an orange, deprived of its contents, and filled with a sponge which had been soaked in vinegar impregnated with various spices, in order to preserve himself from infection, when passing through the crowds which his splendour or office attracted. The first plague raged in 1649, whereas Wolsey died in 1531."[1] The peculiar mixture may have been new then, but that only.

ACIDS GENERALLY.

Acids as fumigants seem to be valuable when the qualities perceived in them by the unaided senses are manifest, as well as in some other cases. The reason of vinegar acting was said by Liebig to be its power of taking up ammonia, and with it the organic substances to which it gave wing. This may be true of all the acids; the bases which are raised beside ammonia will be carried away along with it. Vegetable acids are weak. Fermentation and putrefaction go on in these acids. Animals of a low type are generated in them, and we cannot therefore expect that germs will be destroyed by them. It is probable that they are useful chiefly for re-

[1] Paris's *Pharmacologia*, 6th edit., vol. ii. p. 18. Lond. 1825. In Pereira's *Materia Medica.*

moving that class of unwholesome substance which is produced by chemical action, not by growths.

The number of mineral acids which can be used for fumigation is small. A disinfectant must for fumigation be little inclined to condense. Those spoken of have the required gaseous nature to a sufficient extent. Sulphuric acid has not this quality, although a good disinfectant. Phosphoric acid becomes solid. Arsenious acid is itself poisonous. These three latter are examples of disinfectants or antiseptics that cannot be used for fumigation.

HEAT AND COLD.

The gases spoken of as oxygen, sulphurous acid, chlorine, and nitrous gas, are all destructive. Even muriatic acid is so to a considerable extent. They may be used to purify the air, because they diffuse into it, and leave no corner of the apartment untouched. All these disinfect by destruction. There is a class of agents which disinfects by preservation, if we may be allowed to speak so. These may be called antiseptics. Boyle, who separated chemistry from alchemy, began the modern examination of these bodies, and showed the influence of heat and of cold. Cold prevents the motion of particles : bodies greatly cooled cannot decay, because the parts when cold have no locomotion. Like a regiment frozen in snow, they stand under the most powerful arrest. Animal matter seems capable of being preserved to endless time by cold: witness the frozen elephants or mammoths of Northern Asia. They have probably remained for ages, and why should they change? The cold removes putrid matter out of the air. Dr. Southwood Smith obtained a putrid organic liquid from the atmosphere of an unclean place, by passing it through a tube artificially cooled. Guntz put a bell-jar over putrid matter, and cooled it suddenly, when he obtained drops of a putrid liquid. Cold removes vapour, and with it matters which remain suspended with it. No wonder, then, that cold should prevent some diseases. Cholera evidently avoids it. Cold acts also by preventing putrefaction even when the particles are not arrested by freezing. In all our thermometers we find *temperate* marked at 55° Fahrenheit ($18\frac{1}{3}$ Cent.) A gentleman of my acquaintance always puts on a great-coat when the thermometer is under 56°. This is from independent experience. Putrefaction has been found to diminish to a mere trifle at 54°, or close to it. Above that the gases begin to arise. For this reason a place which is healthy at 53° may become unhealthy at 55°, and most persons will not remark the change of temperature. It is strange that this point in putrefying liquids should be, we may say, quite the same as that of the feeling of cold in the living body.

We must be thankful if in any district ill provided with means of purification, we have less than 54° of heat. Much of the health of this country must be owing to this condition being found in it. Marshy or undrained lands become cold and sour or peaty, and disinfect themselves. In warm countries marshes are much more dangerous, and there we find cold an infecting agent. The night comes, like the bell-jar spoken of, and condenses vapour; liquids with poison in solution fall down as mist. Sometimes we find a little hollow of a field or county filled with this vapour when the plain is free. If any one ventures there he may be injured even if he be only a few feet lower than his companions. We hear in hot countries of men who receive no injury standing, but suffer the fevers and ague of the district if they lie down. This is an action of cold. The Innuit builds his house of snow, and has only a small hole in it; he cooks and burns fat there, but we never hear of fevers and agues from putrefactive matter. The cold no doubt condenses it at once against the ice walls. Rain washes the air in a similar way, and cold and wet certainly produce pure air. If they exist in a country with good drainage and little organic matter, they produce some of the most important conditions of health.

If we do not utter contradictions, we become one-sided; nature to us is full of them. Heat, like cold, is a source of health, and has a disinfecting power. In some cases it is colytic. When the Damaras cut meat into strips and dry it in the sun, the decay is arrested by an act resembling freezing. Dr. Henry showed that even if the poison of disease were contained in clothes, it was destroyed by heat. Vaccine matter lost its power at 140° F., the heat being continued for three hours. At 120° three hours did not destroy it. This corresponds with the temperature of coagulation. At this point, 140° F. or 60° C., something peculiar happens to animal matter, and amongst others it begins to be cooked. Dr. Henry found it needful to heat the clothes of fever patients to 200° F. in order to produce disinfection.

Heat expands bodies, and when the fever matter is condensed over a marshy region, the sun raises the vapour, and it is diluted to such an extent as to become innocent. Cattle-plague does not appear to be diluted in this way, so as to become innocent. Why should heat be called a disinfectant if it promotes putrefaction? It promotes putrefaction and its consequences, especially between 54° and 140°, but this must be in the presence of water. If it is dry heat, it arrests at all temperatures. Even if moisture be present, the disinfecting action is powerful, perhaps all-powerful if the temperature of 140° be continued long; but, as Dr. Henry and others have shown, it is not complete if that point is kept up a short time only. So also for the destruction of dangerous ingredients, in heat we have this point of disinfection, although recent inquiries seem to show that to destroy trichinæ and similar enormities it is well to go higher.

The action of heat and moisture in producing putrefaction is by facilitating motion, but the absence of moisture, *i.e.*, dryness, prevents motion. Girolamo Segato made a table with 214 parts of the human body dried. He also caused the members to preserve elasticity. Some specimens have become sacred. In Hungary they would be called vampires. Chemistry changes; that is, substances act differently, according to temperature. The chemistry of human life goes on between 95° and 100° F.; we resist attempts to raise us above or below these points. The relations of man to nature change with every change of the thermometer, and in every climate a new relation of animal and vegetable life is found. The temperature of the air for man must be between 40° and 100°, although we may endure a little more or less with great inconvenience. All chemical actions differ as the thermometer rises or falls, until blood refuses to take up oxygen; in enormous heats, even hydrogen and oxygen, which we now find combining with violence, would refuse to acknowledge each other.

Berzelius says that animal liquids may be long preserved from decaying by occasionally heating to 100° C. or boiling heat of water, in order to remove the oxygen absorbed. Another says 60° C. or 140° F.

A veterinary surgeon of Germany, W. E. A. Erdt, of Coeslin, in a pamphlet on *Die Veterinaer-Polizei* (Sorau, 1865, p. 11), classifies infectious diseases into volatile at all temperatures, slightly volatile, and fixed; so one disease may be propagated by the air at one temperature and only by contact at another. 112° F. to 140° destroys most, so that hot water destroys nearly all. Glanders is destroyed at 134° F. Hydrophobia about the same; none are destroyed below blood-heat, but some are produced only at a lower temperature,—for example, that from dead bodies. The cold cannot destroy contagion, "it can only bind it, lay it, or render it inactive." So in the north the infectious diseases are milder, or disappear, and contagious are more active, whilst in polar regions they too are destroyed. This idea is opposed to germs, as they cannot be volatile.

Cattle-plague, perhaps, more than any, shows an indifference to season, and flourishes in heat and considerable cold, in dryness and moisture. It is propagated both with and without contact. I think that to consider it as a solid brings the clearest explanation. What kind of solid? Is it a vegetable or an animal particle? Perhaps when it is found nestling in the flesh or the blood of our cattle, it will be difficult to tell its paternity. Cholera, on the other hand, waits for warm weather; its vitality begins, it is very probable, at 54° or 55° F., the temperature of decomposition, and of the incipient feeling of freedom from cold in men. If cholera poison were a liquid, warmth would not tend to concentrate, but rather to evaporate it; but if it were a solid in a state of decomposition, or a solid in solution existing as liquid, the cold would prevent its action. If, however, this arrived at a warm spot, might it not develop? Occasionally we do hear of cases in cold weather. If the poisonous particles pass through the air, they seem to be chilled by it, as dormice are put to sleep, and perhaps never recover their activity except in the case of one in millions. In some such way we must account for their movements; but our chief object at present is to destroy them. We cannot as chemists give rules better than those given; the fumigants mentioned kill organized things, and if poisons are organic, they must be set at rest under the treatment.

TAR ACIDS.

Tar, with its products of distillation, is a complex product. We may refer here to three substances obtained from it. We have wood-tar, giving out creasote, and we have coal-tar, giving carbolic acid and cresylic acid. These substances differ in composition, but their actions are very much alike. We cannot yet give a very close account of their differences. When we speak of ancient times we have to speak of creasote only in all probability, but in looking on its history, a little mixture of ideas will scarcely be a fault. Experiments with both are given further on.

Runge called the body like creasote from coal, carbolic acid, or coal-oil. It really has acid properties, but its composition is analogous to alcohols; and it is strange that several bodies of that constitution should have so much power of preventing putrefaction. Reichenbach obtained it among his many new bodies, which people could not find till long after he did. Properly speaking, Reichenbach found creasote, and Runge carbolic acid, I suppose. Creasote is found in the products of distillation of wood, and of benzoin resin used in fumigation. The tar-barrels burnt in the time of epidemics, from the earliest date till this year, give out this body, but would give out more if the flame were suppressed, and distillation only allowed. The world has admired this substance without knowing its existence, and sought it in every corner, using various names to express it, wrapping it in bundles to carry around them, burning it in pastiles for fumigation, and sometimes in public in great bonfires. Savages use petroleum for their wounds and their cattle, and the most civilized of old times kept in products of tar the dead that they desired to preserve to a joyful rising. Bishop Berkeley tells us that it was used as tar-water in America, the tar being merely stirred up with water, and the water drunk, a glass at a time. He himself had tried it in many diseases, and tells us of small-pox, erysipelas, skin diseases, and ulcers being cured by it; quotes the pitching of wines by the Romans as a proof of its value, and Jonstonus, in his *Dendrographia*, as saying that it is wholesome to walk in groves of pine-trees, which impregnate the air with balsamic particles. The learned writer then goes on to say that, although he may be ridiculed, he suspects tar-water is a panacea; "and as the old philosopher cried aloud from the house-tops to his fellow citizens, '*Educate your children*,' so I confess, if I had situation high enough, and a voice loud enough, I would cry out to all the valetudinarians upon earth, Drink tar-water." What, then, is the wonderful agent after which men have hunted in tar-water? Like all such hopes of men, it becomes less when it is found, but it is still of great value. It is not one thing only, there are many things to be found. We have the tar acids and turpentine, benzole, aniline, acetic acid, and many other things from tar, and each has its place.

Speaking of creasote, Gmelin says water with 1 in 10,000 smells of smoke. Its most wonderful property is its preservation of flesh. It stops flow of blood. It kills beasts, fishes, and insects. Plants are killed, and, like animal substances, preserved from decay. Liebig says also that it was used long before Reichenbach discovered it, as *aqua Binelli*, kept a secret in Italy. The *aqua empyreumatica* of Silesia contained some of it, made by distilling crude wood vinegar with lime.

Carbolic Acid.—Of these substances from tar, carbolic acid has taken the lead. It will be seen that its chief properties were examined by chemists some years ago. Not to go further back than Gmelin's *Chemistry*, or, if earlier, 1843, Liebig's edition of Geiger's *Chemistry*, the crystals melt between 34° and 35° C., the liquid boils at 187° C., is oily, and resembles in smell creasote, burns the skin, which peels off, coagulates blood, but does not stop bleeding; sp. g. 1062 at 20° C.; burns with smoke, decomposed by chlorine aud bromine, gives picric acid when treated with nitric acid. "The relation of carbolic acid to orgauic substances is very interestiug," etc. A solution saturated destroys plants rapidly; coagulates blood; is very hurtful if allowed to touch the eyes; leeches and fishes die in it without convulsions; animals dry up without decomposing; weak solutions of gelatine are not made turbid by it, but strong are; albumen it coagulates to a mass soluble in excess of albumen.

Skins treated with lime become, in a solution of carbolic acid, horny and transparent; laid in water they become soft and slippery, like fresh skins, but don't again become foul. Putrid flesh loses its smell at once; so with excrements. The acid combines with the substance.

Lemaire, in his book *De l'Acide Phénique*, 1865, gives numerous details, and shows fully the truth of the earlier observations, with much additional matter. It has been supposed that its power to stop decomposition is the same as its power of coagulating albumen; but a solution of 1 in 1000 of water will not coagulate albumen, while it prevents fermentation of sugar, and also putrefactiou in certain conditions.

So thoroughly has the belief in tar gaiued ground, that it ranks among the firmest superstitions of the world. There are people now who expect to remove the cattle-plague by marking a cross with it on the wall before the uostrils of their cattle; and when we read Lemaire's book—by a scieutific man who leans on facts—we find him scarcely less euthusiastic than Berkeley himself. We must remember that, although the latter had not modern training in scieuce, he was a mau of genius.

There is neither life nor decay without motion.

Tar acids arrest that motion which takes place in decay. They therefore are antiseptic; they antisept. As soon as the decay ceases, the putrid gases cease to arise. Tar acids are therefore disinfectant. They prevent oxidation, but not of inorganic substances. They don't prevent iron from rusting. The movements there required are too powerful; but in organic substances there is more yielding, and there carbolic acid shows its influeuce by preventing their oxidation. Mr. Crookes, in his report, says that it may be looked on as distinguishing vital phenomena from those purely physical. Pettenkofer, on the other hand, finds that although it arrests fermentation, the ferment preserves its power, aud acts when the carbolic acid is gone. At Carlisle, the use of carbolic acid has beeu employed for years, preventing rot, and preventing the growth of all nupleasant decomposition, so common in soils heavily manured. This leads us to a curious point. It would appear that we can apply such graduated amounts as will arrest putrefaction, which we may call lower organic phenomena, or destroy the vital power entirely. We can then proceed to destroy the higher vegetable and noxious animal life.

It has been asked if carbolic acid destroys infected matter, or merely prevents change in the matter during the time that the acid is present. Pettenkofer[1] says that carbolic acid preserves inert the ferment cells, but when it is removed they become active. If this is true, the disinfectant must be used continuously, and the impure matter must be cleared away continuously, whilst soon in time, and especially in the earth, the infectious matter will die. We must put it out of the position where it will be dangerous. It is difficult to use enough of any disinfectant to destroy poison where life

[1] *Allgemeine Zeitung*, February 4th, 1866.

must be preserved, and impossible to do so instantly where the poison is strong. But these acids render fermenting matter inert, and this is the great object to be first attained. (Experiments since made lead me to believe that Pettenkofer must have used very weak acid.)

Carbolic acid has been made a subject of special study of late by Mr. Crookes. He found that it did not affect the oxidation or action of inorganic substances.

Meat steeped in a one per cent. solution of carbolic acid and then dried, preserved a fresh odour.

The same with skin, gut, etc.

The same with size and glue.

A solution of albumen was very slowly and not completely coagulated by a one per cent. solution of carbolic acid.

A few drops added to half a pint of fermenting sugar and yeast stop the action.

The solution of one per cent. stopped the activity of yeast, but produced no change in its appearance.

Cheese mites, fish, and infusoria were destroyed, caterpillars, beetles, and gnats.

The use of carbolic acid on a large scale was first brought prominently forward by myself and Mr. M'Dougall, so far as I know, about fourteen years ago, but all its essential properties were known before. Mr. M'Dougall by using it in M'Dougall's Powder has made it famous, and its fame has caused a similar powder to be made in other countries and by other persons. He used it also for wounds and for destruction of insects.

For the preservation of manure it is as marvellous as for the preservation of meat, whilst it does not destroy the fertilizing power, but preserves all the elements, as if frozen, from all change.

It was recommended by the author for the prevention of decomposition in sewers and in sewer rivers, until they could be more thoroughly purified. In a treatise on Süvern's *System*, by Dr. Hubert Grouven, the same mode of purifying sewers is recommended, and said to be on trial in Leipzig. The mixture used is a little different.

1 lb. of melted chloride of magnesium.

3 lb. of lime.

¼ lb. of coal tar.

Mr. M'Dougall has long used tar-oil and lime for the land at Carlisle. I still think it would be better to pour this on the streets, and to let it disinfect all that is found there, running it then into the sewers, and preventing putrefaction there, as it is better to prevent than to interrupt the formation of unwholesome gases.

The great advantage of carbolic acid is that it is a liquid slightly volatile, it is therefore easy to throw it down anywhere, and to cause it to penetrate into every corner of a building, or to fill the air of the neighbourhood.

The Appendix to the Royal Commissioners' Report on the Cattle-plague contains the following :—

"According to the principles laid down the air must be treated, and where there is no disease there is only a secondary use in treating anything besides the air.

"Several cowhouses have been treated with carbolic acid with very excellent results. The mode has been first to remove from the floor the mass of manure which too often adheres to it; secondly, to sprinkle the floor with strong carbolic or cresylic acid. Next to wash the walls, beams, and rafters, and all that is visible in the cowhouse, with lime, in which is put some carbolic acid, 1 to 50 of the water used, or with strong carbolic acid alone. Next to make a solution, containing 1 of carbolic or cresylic acid to 100 of water, or perhaps still better 60 of water, and to water the yard and fold until the whole place smells strongly of the acid. Only a few farms have been treated in this way, so far as I know, but in each it has been successful.

"It may be well to give the cattle a little of the weak solution of carbolic acid, but this has not been so fully tried as the external use. The washing of the mouth and entire animal with the weak solution may be attended with good results, especially in the early stage of disease; but I know nothing of cure, and speak only hopefully of prevention. The animals seem to have an instinct for disinfection, and lick substances touched with this acid. They must not be allowed to drink it, as, when strong, as already said, it blisters the skin and especially the mouth and tongue."

The carbolic acid may be used with sulphurous acid, as had long ago been done.

Mr. Crookes made elaborate experiments on this acid, and had great success. The result is given in his Report, from which the following is extracted:—

"It appeared evident that if harm were to follow the injection of carbolic acid, the mischievous effect would be immediate; but that if the fluid could pass through the heart, without exerting its paralysing action on that organ, and could get into the circulation, no present ill effects need be anticipated. I therefore determined to push these experiments as far as possible, increasing the quantity of carbolic acid until it produced a fatal result.

"The next operation was on cow No. 11, in which three ounces of solution (containing 52½ grains of pure carbolic acid) were very slowly injected. No bad effect followed.

"Increasing the dose, cow No. 12 had injected into her vein 4½ ounces of solution (equal to 78¾ grains of carbolic acid); this also was followed by no immediate ill effect.

"Cow No. 13 was then treated with six ounces of solution (containing 105 grains of pure carbolic acid) in two portions of three ounces each; five minutes' interval elapsing between each injection. The first three ounces produced a slight trembling, but not so severe as in the case of cow No. 10; as she seemed better in a few minutes, the second dose of three ounces was injected. This proved too much, or was pumped in too hurriedly; for almost before I had finished, the animal trembled violently; its eyes projected; its breathing became laborious; it fell down and expired.

"The result could scarcely be attributed to the accidental injection of air iuto the vein, for the distress bcgan with the injection of the first syringeful, and was only increased by the second; nor is it likely that this accidcnt would happen twice consecutively. I was particularly carcful on this point, and the construction of the instrument rendcred such an occurrence scarcely possible with ordinary precaution. It is probable that the injection was performed too rapidly, or that the vital powers were lower than usual.

"In the case of the remaining animal, No. 14, I decided to inject as large a dose as it would bear, stopping the operation at the first sign of trembling, and delivering the liquid very gradually. Thc first syringeful caused no bad symptoms, and I had just fiuishcd injccting the second dosc when trembling commenced. It was rather violent for a short time, but soon went off, and iu five minutes the animal appeared as well as before. This cow, therefore, bore without inconvenience the injection of six ounces of a four-per-cent. solutiou, containing 105 grains of pure carbolic acid.

"Careful observations with the thermometer were taken before each operation. There were no more diseased bcasts on the farm, or I should have carried my experiments still further.

"On visiting the farm the next day I was told that all the animals seemed better, and on testing them with the thermometer, that statement was confirmed. I gave directions that each animal was to be drenched with half a wine-glassful (one ounce) of carbolic acid in a quart of warm water every morning; but in other respects they might be treated as Mr. Tomlinson, a skilful cow-doctor, should direct.

"Business now calling me to London, I was unable to watch the further progress of these cases; this is to be regretted, as a series of daily thermometric observations would have been of great value in suggesting further experiments. I had, however, frequent accounts sent me. Cow No. 14 continued to improve slowly, until convalescent. She is now quite well. Nos. 10, 11, and 12 remained in apparently the same state for four days; they then changed for the worse and died. It is not improbable that, had I been able to inject a further quantity of carbolic acid, during the four days in which they were thus hovering between recovery and relapse, it would have turned the scale, and some of them, at all events, would be now alive and well.

"The following table gives the thermometric observations:—

"*Table showing Results of Injecting Carbolic Acid into the Blood of Animals suffering from the Cattle-Plague.*

No.	Grains of Carbolic Acid injected.	Temperature before Injection.	2d Day.	3d Day.	
		°F.	°F.		
10	26½	105·4	103·8	Better.	Died on 6th day.
11	52½	103·8	102·8	Better.	Died on 6th day.
12	78¾	104·8	104·4	Better.	Died on 6th day.
14	105	103·7	103·1	Better.	Recovered.

"If future experiments prove that injection of carbolic acid, or other antiseptic, will do good, it is an operation very easily performed. I have injected five animals, and taken thermometric observations, within an hour. Sulphite or bisulphite of soda apparently occasion some pain, as the animals struggle very much. With carbolic acid, I found them tolerably quiet.

"I have calculated the proportion which the carbolic acid bore to the whole quantity of blood in these operations. Taking the whole amount of blood in the animal at 150 pounds, there were injected into—

No. 10,	one part	carbolic acid in	40,000	of blood.
„ 11,	„	„	20,000	„
„ 12,	„	„	13,300	„
„ 14,	„	„	10,000	„

"It is worth mentioning, incidentally, that in the case of cow No. 14 (which recovered), the proportion of carbolic acid injected into the blood would have been enough to keep from decomposition the whole quantity of that liquid for a considerable time. In Nos. 10, 11, and 12 the proportion of carbolic acid would probably not have been sufficient for that purpose.

"I am informed by Dr. Calvert that cresylic acid has much less coagulating power on albumen than carbolic acid, and my own experiments entirely confirm this statement."

Since we worked at the subject another has taken it up, and we find in the *Gardeners' Chronicle*, November 9, 1867, a description is given by the Hon. W. Hope, of experiments made on diseased cattle at his farm near Barking. He says: "I thought that while there was life there was hope, and I determined to do more than anybody had done before. Where one man had used a hundredweight of lime, I determined to use a ton, and where one man had used a pint of carbolic acid, I determined to use a gallon. . . . The dry substance I had at hand to deal with in large quantities was lime. This I slaked in small pyramids in the centre of the sheds. I also laid trains of it outside the sheds, underneath the ventilators, and then slaked it. I also smothered the roads and paths at different points in layers of quick-lime three or four inches deep, so that every man and animal would be compelled to pass it. After scouring out the sheds, every cow's tail was dipped into a bucket of carbolic acid and water. Their heads and noses were dabbed over with it, also their sides and flanks. All the manure and litter from the cow's stall as well as from the adjoining ones was taken out at once, and the floor thoroughly cleansed and saturated with carbolic acid; and, on the suggestion of Professor Brown, I had four days previously commenced the use of sawdust saturated with carbolic acid, one or two shovels-full of which were placed every day underneath the cow's head. This operation was also repeated in each stall, and the cows were then drenched with gruel and sulphite of soda." He then adds,—"Of the fifty-eight cows in shed F, and fifty-three in shed E, that I took the entire charge of, and treated as described, I did not lose one. Two that had been condemned to death were 'smuggled' out and exchanged for two others of less value. These two condemned had been in actual contact with diseased animals in every stage of the disease, in no less than three infected, and highly infected sheds, and were even placed beside a diseased animal in a shed which had been emptied of diseased animals suffering from the most virulent type of the disease for a couple of days, and had only been disinfected for thirty-six hours."

Cresylic acid is another tar acid which has not been rendered crystalline like carbolic. I am disposed to believe it to be more powerful than carbolic. It has a stronger smell, and so far is objectionable.

SOLIDS, SOLUTIONS, SALTS, ETC.

TAR.

MUCH of what has been said regarding carbolic acid may be said of tar, of tar oils, and of petroleum crude. Although I do not know that petroleum contains exactly what we call carbolic acid, it seems to contain a substance closely allied, but in small quantities.

Petroleum is a very poor disinfectant compared to tar acids. Probably the petroleum has a little either of carbolic acid or an allied compound, to which it owes all its disinfecting power. Tar oils, which most resemble petroleum, have also a weak disinfecting power; and when the carbolic, etc., acids are washed out there is no disinfecting power remaining.

Tar-water has been spoken of. Tar oils were dissolved in water by means of lime, and used for the sewage when put on lands by Mr. M'Dougall. There may be an advantage in cheapness by using the crude substances, but when we eliminate the most powerful part of the tar, we have probably a more constant strength to deal with, and we save bulk and appearance. Süvern, as already said, uses tar itself for the sewers, dissolving by means of lime; and the following concerning Grandmaison may be quoted from the *Chemical News* of May 1, 1868 :—

Tar-Water.—"The medicinal properties of tar-water, administered externally and internally in the treatment of various diseases of man and other animals, are well known. Up to the present time, this solution has not been manufactured in such a way as to contain a fixed proportion of tar. M. Guzot de Grandmaison, an intelligent chemist, has succeeded in obtaining a tar liquor perfectly capable of mixing with water, and containing a certain percentage of resinous matter. The application of his concentrated definite tar liquor has been attended with the greatest success, and this new preparation has, according to a report of one of our best practitioners, '*comblé une véritable lacune*.' Several trials were made with this article in fifteen public hospitals in Paris, with the best results. This is a most natural consequence of the solution of tar, containing in a small volume all the active and medicinal portions of the tar, to the exclusion of the bitter empyreumatic principles always disagreeable to a sick palate, and often injurious to certain affections. No foreign substance is allowed to enter that can alter, suspend, or complicate the expected and precise effects of the medicament. The effects are produced by the tar alone, and by no other ingredient. Starting from the fact that two tablespoonfuls of the liquor, added to a litre of water, constitute a tar-water of average strength, and always constant, it is easy to increase or diminish the intensity at will. Pure, or mixed with water, the concentrated tar essence can be put to a variety of new usages which were not available for want of a convenient method of administration; in fact, ordinary tar-water was so slow in action that it had almost been set aside."

LIME.

Lime and alkaline earths disinfect. Lime does so partly by absorbing gases and vapours, partly by neutralizing acids formed during putrefaction, partly as a porous body. All that it does is not quite clear, but seems to be connected in some manner with that change of chemical decomposition which an alkali produces in a decaying body. As a disinfectant it is comparatively weak, but it is cheap in most places, and can be used in great quantities. We may obtain great effects by overwhelming with it all substances giving out noxious gases and vapours, and even absorbing such after they are given out. Thrown on putrid matter, a fresh smell is rapidly produced, and sooner or later ammonia chiefly can be perceived. The most unpleasant rooms are made fresh and agreeable if the walls are well limewashed, nor have we any reason to suppose that any unpleasant or unwholesome substances will continue as such after the application. Abundant limewash is an excellent remedy for want of cleanness in surfaces where actual washing is difficult. If it is feared that the air entering is not quite pure, it is well to mix with the limewash some carbolic acid. During cattle-plague, it is probably quite sufficient to whitewash pens and the trucks in which the cattle are conveyed, but this must be done so frequently that there is little hope of having it done efficiently. But if carbolic acid is present, the air from the pen ceases to be a centre of infection. If the cattle are to travel by rail, the truck ceases to be a mode of carrying disease over the whole country, sending out germs, if germs exist, into every field that is passed.

If lime, as a disinfectant, is compared with chloride of lime or carbolic acid by bulk, it is very weak indeed; and as it is not volatile, it cannot affect substances already in the air; but the value of lime, and the whole secret of its use, lies in the fact that over surfaces of lime the air is fresh and wholesome. This is true as a rule, but it must be explained without severity, as the surface of lime may be very thin, and the depth of impure matter below very great. When a house smells musty a thin coating is enough, but great heaps of impurity require great thickness of lime, so much so that it is not convenient to use it in such cases.

Dampness may be removed from a room, when fires will not remove it, by the use of lime, but then it must be thrown by hundredweights on the floor.

For purifying stagnant and unpleasant water of manageable bulk, lime is most valuable. It is thrown in as milk of lime, which is simply burnt lime, to which water has been added, until it falls to a powder, then in greater quantities.

It may even be used for small portions of malarious soil near dwelling-houses, exactly as it is used for destroying the acidity of soils as well as their vermin. It is used to cover the bodies of dead animals, especially if diseased, when the graves are not very deep; it is also used to cover heaps of vegetable matter, and, according to the germ theory, this is exactly what we do in whitewashing.

The use of lime is one of the best modes of purifying water. It takes down with it nearly all the organic matter, and certainly all that is most active and dangerous. The most muddy water is rapidly cleared by it, and frequently becomes pleasant and wholesome to drink immediately after treatment and subsidence. The process invented by the late Professor Clark of Aberdeen is capable of removing much more than the mere hardness of water.

Lime seems to keep wholesome those corners that receive little light or heat. A corner of this kind is generally found near our houses, or in gardens damp and unapproached, and frequently devoted more to the lower insects than to healthy vegetation.

SULPHATE OF LIME, OR GYPSUM.

This substance has been highly lauded as a disinfectant from its power of absorbing ammonia, and people have begun to consider ammonia dangerous, seeing that it is desired to absorb it. Ammonia itself has a pleasant odour, but there are objections to it from decaying matter, because it often accompanies deleterious substances, and its loss is a loss to the farmer; it is the most important ingredient in the food of plants. Sulphate of lime, having a great power of absorption, is useful when it absorbs ammonia, which no doubt contains some other vapours which pass off along with it, but soon the sulphur is deoxidized and comes off along with hydrogen, if there is much moisture. This sulphuretted hydrogen is not accompanied with much organic matter, but it is nevertheless unpleasant, as well as unwholesome. It is not carried far, but it destroys the comfort and appearance of all around it. Paint, if it contains lead, as it generally does, becomes black before it. When much water is not present, gypsum is apt to become caked and unmanageable; but if in powder, and pretty dry, it is somewhat useful in a few cases. When it can be used in very great quantities so as to absorb the moisture, say of cowhouses, etc., it is quite effective in allaying products of decomposition also. It has no effect in purifying water unless it is used in enormous quantities. Then it hardens the water to the utmost.

METALS, ETC.

Metals for fumigation have not been mentioned. It has often been said that Birmingham has been extremely free from cholera, and the possibility of metallic exhalation filling the atmosphere has entered men's minds. It is not impossible.

In a place where copper is being soldered, we may smell it readily; where lead or zinc is melted, it may be seen as a white oxide on the walls.

It may be that metallic fumigation would prevent disease, but as a rule it seems not wholesome, and it is not easily managed. The use of arsenic does not seem to be an advantage to men in this country, although in Styria and other parts of Austria it is admired both for plants and animals. Perhaps we do not administer it with that care and system so instinctive among races more purely German than we are.

The neighbourhood of chemical works has always been considered remarkably free from infectious disease, and in the streets around one of the largest in the country, this was remarked by the workmen themselves. These men sometimes discover things that the better informed quite miss; they have no theories. They come with bronchitis to a chemical work, and bring their children to the sulphur-burners to be cured of hooping-cough, and discover for themselves the disinfecting powers of chlorine, muriatic acid, sulphur, and metals; admiring the wonders of nature without caring to infect the world with their knowledge. They are like tender feelers put out by society. Scientific men ought to take up their slightest fancy, and bring it up into a thought which will in many cases be true and valuable. There may be good mixed up with the evil.

METALLIC SALTS.

Metallic salts are powerful disinfectants, and in reality the most powerful antiseptics. We must regulate their use according to price and wholesomeness. Mercurial salts, which Kyan used for timber, cannot be applied in daily life, because so poisonous. Sulphate of copper is almost equally powerful.

Arsenic has much power, also chloride of arsenic. The value of chloride of zinc has been long known in Sir William Burnet's Disinfecting Fluid. Chloride of aluminum has some disinfecting properties, still more nitrate of lead, both in virtue of its lead and its nitric acid. Chloride of iron has been much recommended for sewer water, and its cheapness will probably keep it in favour. Sulphate of iron is good, but, like most of the sulphates, causes sulphuretted hydrogen, which is absorbed in many cases by the iron, but not in all. As a rule, however, that gas is absorbed; and the great use made of the salt in Germany is much in its favour. Acetate of iron was used by Boucherie in a strange manner. Instead of driving the antiseptic into wood as Kyan did, he fed trees with the salt, and when they had taken it into their sap they were cut down. All these metallic salts must be used in a very diluted state, or they cause very unpleasant vapours to rise, instead of stilling them, and none of them affect substances in the atmosphere. They, however, effectually prevent any putrescible substance from affecting the air, although, not being volatile, they do not attack bodies which have already managed to rise into the air of any enclosure.

A very little need be said of the metallic salts beyond the fact that they are powerful in preventing decay. A few specimens may be given. Waterton used corrosive sublimate for preserving skins of animals. The skin was dipped into the solution and dried. Vernet used arsenic, 1 lb. in 40 gallons of water. Sulphate of zinc was proposed for embalming by Louis Fontainemoreau, adding also alcohol when needed. Dr. Ure recommends a solution of corrosive sublimate and wood vinegar.

Chloride of manganese, a substance usually thrown away, may be used, as Guy Lussac and Mr. Young have shown, and sulphate of manganese has also been employed.

The salts of iron and manganese are innocent, and we know little of the harm which zinc can do.

The bulk of the metallic salts required is small, and the efficiency is great; but the most efficient are the most poisonous. The colytic power that stops the action of decay, stops also the action of life, and we must take care not to bring it into operation within living beings, except to a very small extent.—*See experiments.*

ALUM.

Salts of alumina, and notably alum and sulphate of alumina, have a peculiar power of combining with organic substances. Alumina becomes by this property an important substance in dyeing, by acting as a mordant, taking a firm hold of the cloth. The action has been long observed, and has been likened to biting, hence the name.

Alum is used extensively in India to remove the unwholesome bodies floating in impure water. It certainly acts powerfully. Care must be taken not to use too much. It is only advisable in very bad cases. The biting power gives alumina its preserving property, but it does not seem to possess it very long in watery liquids, because of the acid losing its oxygen. Sulphates are all apt to decompose, and it is only when metals are with them to take up the sulphur that they can be kept long in liquids with organic matter. Still I think we do not know enough of the preserving power of alum. This action on organic matter is especially used in this country by bakers to destroy the parts of flour beginning to decay, or at least to keep it from acting injuriously in the bread. Inferior flour is made by alum to give bread a superior appearance. If the alumina is precipitated, or removed from the acid, as may occur where small quantities only are used, it is possible that not only no evil may follow, but a great gain may occur by making inferior food palatable and perhaps wholesome. This requires examination. An abuse is the corruption of a use.

COMMON SALT.

Common salt is used as an antiseptic; it is the original antiseptic. We have sought to improve upon it, but we still use it, and it will probably be used for ever. It is used for preventing putrefaction in food; why should it not be used for preventing refuse substances of all kinds from decay? The experiments tried with it were most successful, when it was compared with other disinfectants, as to its power of preventing the evolution of gases from blood. It is extremely probable that it will turn out one of the best and cheapest, as well as one of the most convenient and agreeable. It was used in part by Mr. Southwood at Hyde, when he tried an experiment on the cleaning of towns, and very successful the experiment was. Another substance was used, which he wished me not to speak of, but I rely on the salt.

I am sorry I have confined my experiments on salt to the laboratory, but its great and long-known value as an antiseptic may give us confidence in using it in a larger field.

It has not the power of removing smells, as will be seen under that head. An estimate of its value will be seen on a later page.

SOIL.

One may very correctly look on the soil as the greatest agent for purifying and disinfecting. Every impurity is thrown on it in abundance, and yet it is pure, and the breathing of air having the odour of the soil has, on what exact evidence I do not know, but very generally, been considered wholesome. In the Memoirs of the British Association for 1851, I remarked: "Let us suppose the soil dried up, the decomposition would cease. Let us suppose it not dried, but kept constantly moist and cold, and we have the ground in a state, described in a very interesting manner by Bernardini Ramazini, producing a disease which is not unlike the potato disease with us. But it went much further; all vegetation was blighted, the food bad, and health bad, the very animals returned the food they had eaten, it was so nauseous; the waters became corrupt, and fever attacked the inhabitants. It was right, therefore, to call attention to the limit which there is to the power of the soil. We must learn not to give it more to do than it can. The existence of malaria where there is little organic matter shows that with some soils the limit is soon attained."

When reading Macculloch on malaria, we begin to fear the existence of the slightest moisture on the ground, although from other good authority we hear that the same evils arise where the influence of moisture does not occur. In malarious districts we learn that the evil is greatest when the soil is turned up. Still we know that the soil does absorb all kinds of impurities arising from putrefaction, and destroys them, but there are limits to its power. We must learn not to give it more than it can accomplish, by flooding it with matter that will become foul, especially if wet; still it will bear much if there is a current of air insured through it. Many persons, remembering the paddle of Moses, insist on the use of earth only. As has been said of lime, it is a disinfectant which will not compare with metals or tar acids, if we look at bulk. How this objection is to be met we must learn in time. Here the question is not intended to be discussed. It will be sufficient to give the Rev. H. Moule's mode of disinfection in his own words, and to add, that the Indian Government is said to have adopted the system, whilst at the same time it sent him a reward.

Mr. Moule says: " The first requirement for the proper use of the earth-closet is earth perfectly dry and sifted.

" Earth alone is proved to be the best deodorizer, and far superior to any disinfectants; but where it is difficult to obtain earth abundantly, sifted ashes, as before stated, may be mixed with it, in proportion of two of earth to one of ashes.

" The earth commode and closet for six persons will require on an average two hundredweight of earth per week." The system is arranged by a compauy for houses, and for towns, barracks, and work-houses, etc. Nobody cau doubt the disinfecting power of the soil, and ccrtainly Mr. Moule has found a mode of applying it in very many cases.

Dr. Lloyd of Anglesea had a similar idea of disinfecting, by the use of refuse cinders. And Mr. Goux proposes to use the sweepings of towns and all other carthy refuse that can be had dry. As slow means of rendering less injurious the substances so difficult to get rid of in our towns, it is well to havc them tried.

These substances are disinfectants in a secondary manner, as their bulk and porosity enable the air to act on the substances they enclose. For country places the plans may be excellent, even when large towns cannot use them.

The part of the subject to which this alludes is not pleasant. I heard a friend say that we have become so proud that we are ashamed of our humanity. There is a certain truth in this, and nature has made us so. In working on disinfection, I used blood almost entirely, but the smell was often so bad that I was driven back, and had it not been for an assistant who did not in the least feel annoycd, I certainly should never have been able to give the experiments published on putrefaction.

MANURE.

We desire to prevent from decomposition the manure, from which it is the problem of Europe to escape. It produces a class of disease which we generate and foster at home, and assists its relations when they come, like cholera, to visit it from abroad. We must treat them as we proposed to treat our enemies in the air; but here we have large quantities, and we need not send invisible agents to do their work unseen, leaving its completeness a problem difficult to solve, although soluble. At present there are two plans: one is to overwhelm with water, and to carry off in unseen underground streams; another is to leave the material as dry as possible, the moisture having been drained and passed into the atmosphere or the soil. The first-mentioned, the water-closet system, is a great luxury unquestionably, but, like luxuries, it is taxed. Water is the most powerful agent of infection known to us as well as of disinfection. Substances which preserve for ever dry, become putrid at once when moist. All organic bodies decompose most rapidly in it, aud if it is sent out of our towns laden with riches, it rapidly dissipates them all and sends them into the air. It is the very symbol of abundance and extravagance. Manure will not keep in it, and will not carry in it long. Cesspools, which were deposits of manure and water, were found after much loss of life to be manufacturers of disease of the most active nature, and water-closets which are not carefully attended to obtain an odour by no means agreeable. Water is called a disinfectant, because it is a vehicle for oxygen and a solvent of organic bodies, which then act rapidly, dissipating their products in the air, and also because it removes mechanically. If there is much water and much air present, the oxidation is complete, and the resulting gases are sent out pure; but if there is much work to do, the water will not wait, but rapidly sends out its gases half purified. The mechanism of the water-closet system must be very excellent, and with the best a little chemical assistance from disinfectants is often needful to insure comfort at home and avoid loss of property abroad. If, however, it is well managed, who can doubt its beauty? It is the removal of a curse from man's nature, a curse which weighs him down the more he becomes civilized in towns.

Still all the world cannot have water-closets. You cannot have them in Norway—they would freeze,—nor in Arabia, where there is want of water, nor in many other places. The midden is apparently destined to continue as an attribute of man; certainly of his ox, and his horse, and his ass, and his pigs, who leave it to him to clean up after them. The problem for stables is quite solved by disinfectants. If left to dry, the amount of mischief done by manure is infinitely less than by the cesspool. The liquid goes into the soil, which, if porous, will oxidize, as we have seen, forming nitrates and carbonic acid. If it cannot flow into the soil it will act injuriously, as cesspools on a smaller scale, and this it does, although not quite so violently, because, being more exposed to air, the products are more oxidized. It is the products formed in moist inaccessible places void of light, which, like deeds of darkness, are most to be avoided. The dry part of the manure is less hurtful, because it only gives out what the oxygen comes to take away. It rarely, however, lies long quite dry, and the evil is never reduced to nothing, although we have got rid of that terrible form, the cesspool. We can distinctly prove the air over all such accumulations to be bad, by analysis as by the senses. We should like to know how it genders and feeds disease; we know it does it within certain limits.

We live over a mass of putrescent matter in sewers; the water increases its activity. We have heard of some persons causing a laugh by saying, "No, we have no sewers; we would not live near such filthy things." They had reason: there are sewers and sewers. The liquid matter, when neither removed rapidly nor disinfected, is our old enemy the cesspool, with a territory extending miles long instead of feet only, as in old times. The midden is better than the bad sewer. We find it not easy to obtain the theoretically good sewer of the Board of Health, which allows of no accumulation. Some engineers think the matter is not bad till it putrefies. We cannot agree.

This book is not intended to solve the great problem of purifying towns, but to collect some information useful in that direction. This part may be spoken of more fully elsewhere; but I believe we shall never see the extinction of either middens or water-closets. We must not be one-sided.

CHARCOAL AND FILTRATION OF AIR.

Charcoal, etc.—If the substances to be disinfected are in the air, it is useless to employ solid bodies—gases and vapours only can reach them. We might, it is true, filter the air entirely, say through charcoal, as Dr. Stenhouse proposes, and into our rooms or cow-houses allow no breath to enter that had not been purified. The charcoal, especially if platinized, would extract all the poisonous substances. It is not yet known how far this process is manageable. That substance, charcoal, is now used as a purifier of sewer gases, which afford it a wider field for its activities; the gases which leave the sewer pass first through it, and enter the air free from odour and danger. The sewer air often requires filtration ere it rushes into the streets. It is frequently very bad. Engineers ventilate the sewers and also filter the air, but refuse to apply disinfectants. They say that disinfectants ought not to be required; that with sufficient cleanness they are unnecessary. Where is the sufficient cleanness to be had? Certainly not by any mode adopted. Disinfectants are bad, but bad air is worse.

To allow bad air to form in the sewers, and then to draw it out into the town is certainly objectionable. If we can prevent it forming in the sewers we are much safer; the next best thing is to filter it. The worst of all is to let it out into houses, and it is almost as bad in the streets.

There are, however, other agents for washing air, but the mechanism of washing is an objection; we can never be sure that every floating particle is reached. Some persons will strew the ground with charcoal; the air will be absorbed and purified when it comes to the charcoal, but when it does not come there can be no action upon it. The same observation applies to all liquids and solids: they are valueless against an enemy which comes, like air, in invisible gas or vapour, unless they can be compelled to mix with it.

Mr. Goldsworthy Gurney passed the air for the Houses of Parliament through a fine watery spray, made by throwing a slender jet of water against a metallic plate or button.

COMPARATIVE POWER OF DISINFECTANTS WHERE WATER IS USED.

There has been no mode hitherto of comparing disinfectants, and a series of experiments was therefore made for the purpose of obtaining the actual values of these bodies in numbers. I cannot say that thorough success is yet attained; more labour is wanted; but we learn a good deal from the following, and probably a fair measurement of value.

The method in which the inquiry was made was as follows: It was first determined to treat blood with small and constantly increasing quantities of the several disinfectants, in order to reach the point of perfect disinfection.

As it was impossible to obtain uniformity without removing the clot of the blood, the serum only was employed, and, as it was found inconveniently thick, it was mixed with twice its volume of water. It was believed that the gases escaping in this condition would be a measure of the amount and quality of the decomposition. The first experiments are made, but, as it will easily be seen, a very long series is requisite to arrive at the desired results. It would be impossible to finish these inquiries for the present report, but, as they already stand, a considerable amount of information is to be obtained. It is already seen which are by far the best disinfectants, but it is not clear to what extent the decomposition of organic matter proceeds along with the appearance of sulphuretted hydrogen. It is quite possible that that gas may diminish the amount of organic decomposition. It evidently arises from sulphates, and is not always a measure of organic matter, although itself bad enough. The rapid evolution of sulphuretted hydrogen was considered as one indication of imperfect disinfection; but with the sulphates this did not tell well. It may be that it is enough, and sulphuretted hydrogen may be considered as itself a sufficiently offensive gas, but, bad as it undoubtedly is, it cannot be considered as promoting the growth of these organic substances or organized germs which we are supposing to be still more insidious. The best disinfectants on merely moist substances become much inferior when solutions are used. We see this with carbolic acid. We see also the influence of water on the sulphur compounds. The great effect of common salt is seen, of high oxides, and of metallic salts.

Amount of Gas evolved when Disinfectants act on Organic . Substances in Water.

	CO^2.	HS.	Total Cub. Cent. of Gas collected.	Cub. Cent. per Week.
DILUTE.				
Blood, alone, . . .	86·72	13·28	35 days, 260 c.c.	52
Blood, alone, . . .	69·00	6·68	12 ,, 65 ,,	38
Blood, disinfected by—				
M'Dougall's powder $\frac{1}{1000}$,	70·56	4·74	6 ,, 90 ,,	105
M'Dougall's powder $\frac{1}{500}$,	82·16	10·40	8 ,, 65 ,,	57
M'Dougall's powder $\frac{1}{250}$,	76·66	16·38	8 ,, 65 ,,	57
common salt $\frac{1}{1000}$,—				
1st portion, . .	84·26	4·62	18 ,, 65 ,,	25·2
2d portion, . .	94·93	2·53	26 ,, 130 ,,	34·3
3d portion, . .	81·07	1·92	49 ,, ... ,,	...
carbolic acid $\frac{1}{10000}$, .	29·02	7·31	24 ,, 65 ,,	18·96
do. $\frac{1}{1000}$, . .	69·89	6·80	17 ,, 65 ,,	26·7
do. $\frac{1}{250}$, . .	64·42	4·52	*8 ,, 69 ,,	60·3
cresylic acid and sulphite of soda $\frac{1}{1000}$, . .	57·85	6·66	*9 ,, 95 ,,	73·5
cresylic acid and sulphite of soda $\frac{1}{500}$, . . .	71·02	10·00	18 ,, 65 ,,	25·2
chloride of lime and sulphuric acid $\frac{1}{1000}$, . .	45·22	4·64	12 ,, 65 ,,	37·9
chloride of lime $\frac{1}{1000}$, .	78·61	4·20	15 ,, 65 ,,	30·3
cresylic acid $\frac{1}{1000}$, . .	66·99	3·96	17 ,, 68 ,,	28·0
chloride of iron $\frac{1}{1000}$, .	17·64		... ...	70
sulphite of soda $\frac{1}{1000}$, .	82·72	4·30	10 ,, 85 ,,	59·5
nitrate of lead $\frac{1}{1000}$, .	87·84	4·72	11 ,, 80 ,,	51
lime $\frac{1}{1000}$, . . .	75·79	5·10	10 ,, 100 ,,	70
chlorate of potash $\frac{1}{1000}$, .	61·83	1·77	19 ,, 85 ,,	31·3
common salt $\frac{1}{500}$, . .	85·21	7·11	*12 ,, 69 ,,	40·25
nitrate of iron $\frac{1}{1000}$, .	62·37	7·02	21 ,, 70 ,,	23·3
sulphate of iron $\frac{1}{1000}$, .	89·53	10·47	21 ,, 70 ,,	23·3
sulphate of alumina $\frac{1}{4000}$,	39·58	9·63	24 ,, 80 ,,	23·3
iodide of potassium $\frac{1}{1000}$,	42·97	10·59	7 ,, 78 ,,	78
sulphite of soda and carbolic acid, . . .	78·00	10·32	18 ,, 69 ,,	26·8
chloride of iron, $\frac{1}{1000}$.	85·36	9·94	42 ,, 325 ,,	54
phenyl alcohol $\frac{1}{500}$,. .	51·17	4·26	21 ,, 69 ,,	23
Blood, treated with—				
$\frac{1}{1000}$ chloride of zinc, .	Not sufficient evolved for analysis.		22 ,, 4·5 ,,	1·4
arsenious acid, .	,,	,,	20 ,, 4·7 ,,	1·6
bichloride of mercury,	,,	,,	20 ,, 13 ,,	4·5
sulphate of copper, .	,,	,,	20 ,, 9 ,,	3·1

* The bottles marked thus were by accident subjected to an increase of temperature to the extent of 20° F. or more, thus causing an acceleration in the rate of evolution. The hydrogen and hydro-carbons were too small in amount to be estimated, and stand as nitrogen.

It seems well to avoid in all cases the use of much liquid. When liquids are used in great quantities, disinfection becomes difficult. Blood, as it flows from the animal, is preserved untainted by a small amount of carbolic acid; if diluted with water, a very large amount is wanted, continually requiring renewal. This is an objection to all very deliquescent substances, but when water cannot be avoided, the last four in the above table are clearly the best. It is, on the other hand, a point greatly in favour of all solid disinfectants which absorb water. It is in favour of charcoal, although, as already stated, there are other points against it, not forgetting its colour. It is in favour of lime, and it is also strongly in favour of any disinfecting powder, when it is used in dry places where there is no more water than it can readily absorb. For the same reason, such washing as will leave a place for some time damp is to be avoided when it is desired to disinfect.

In these experiments, chloride of zinc is the most efficacious of the substances tried in one respect, and in another corrosive sublimate, then come arsenious acid and sulphate of copper; but the chloride of zinc far surpasses the others, as tried by the air test in conjunction with permanganate of potash. The carbolic and cresylic acids, which experience has shown to be generally so active in the prevention of putrefaction, are not sufficiently enduring when a large quantity of water is present. It may be remarked that the permanganate and air test is very severe, but, notwithstanding, the vapour from the blood treated by chloride of zinc failed to affect the colour, which was indeed very delicate in tint.

This is not an objection of great strength to the use of tar acids, if we do not keep the substances long under water. Still, some liquids, such as blood, keep with them for months.

Chloride of iron does not stand very high here, although it stood prominent in a class of experiments not detailed.

PREVENTION OF SULPHURETTED HYDROGEN.

EXPERIMENTS to determine the Amount of each of the following Substances necessary to prevent the evolution of Sulphuretted Hydrogen.

Substances.—Arranged in Groups.		
Acids and Alcohols.	Mixtures, etc.	Salts.
Carbolic.	Lime.	Alum.
Cresylic.	M'Dougall's powder.	Bichromate of potash.
Hydrochloric.		Chloride of aluminum.
Nitric.	Heavy oil of tar; water solution.	Chloride of lime.
Sulphuric.	Heavy oil of tar; soda solution.	Sulphite of soda.

These experiments were made on a mixture of equal parts of nearly fresh blood and water. 400 cubic centimeters were put into a bottle capable of containing about 1000 c. c., or about 14 ounces were put into wide-mouthed bottles which could hold about 36.

Three experiments were tried with each, using 1 per cent., $2\frac{1}{2}$ per cent., and 5 per cent. of the disinfectant. Each bottle, properly labelled, was kept four days at a temperature varying from 50° to 60° F. (10° to 15·5° Centigrade), after which it was kept in a water bath which ranged from 80° to 86° F. (26·6° to 30° Centigrade). The contents were examined daily.

HS means Sulphuretted Hydrogen. The table is abridged.

Substance used.	Quantity.	Temperature.	Odour on Second Day.	Day on which HS appeared.
	Grammes.	° Fahr.		
Carbolic acid, .	0·01	From 50 to 60.	Slight odour of blood, .	8th
	0·025		Do. do. .	7th
	0·05		Very faint odour, . .	7th
Cresylic acid, .	0·01	Between 50 and 60.	Slight odour of blood, .	8th
	0·025		Very faint odour, . .	10th
	0·05		Do. do., . .	7th
Hydrochloric acid, (Sp. gr. 1·03.)	0·01	Between 50 and 60.	Odour of stale blood, .	8th
	0·025		Do. do., .	...
	0·05		Do do., .	...
Nitric acid, . (Sp. gr. 1·08.)	0·01	Between 50 and 60.	Slight odour of blood, .	10th
	0·025		Do do., .	...
	0·05		Do. do., .	...
Sulphuric acid, . (Sp. gr. 1·17.)	0·01	Between 50 and 60.	Odour of stale blood, .	8th
	0·025		Do. do., .	...
	0·05		Do. do., .	...
M'Dougall's powder, . .	0·01	Between 50 and 60.	Strong odour of stale blood,	6th
	0·025		Slight odour of stale blood,	...
	0·05		Odour of stale blood, .	...
Heavy oil of tar, (Soda solution.)	0·01	Between 50 and 60.	Slight odour of blood and tar,	8th
	0·025		Odour of blood and tar,	...
	0·05		Do. do.,	7th
Heavy oil of tar, (Water solution.)	0·01	Between 50 and 60.	Odour of stale blood, .	7th
	0·025		Do. do., .	10th
	0·05		Do. do., .	later
Sulphate of alumina and ammonia, (Alum.)	0·01	Between 50 and 60.	Slight odour of blood,	6th
	0·025		Very slight odour of blood,	...
	0·05		Do. do.,	7th
Bichromate of potash, . .	0·01	Between 50 and 60.	Sour odour, . .	None in 10
	0·025		Do., . . .	
	0·05		Odour of fermenting sugar,	
Chloride of aluminum, .	0·01	Between 50 and 60.	Slight odour of stale blood,	Do.
	0·025		Do. do.,	Do.
	0·05		Do. do.,	Do.
Chloride of lime,	0·01	Between 50 and 60.	Slight odour of stale blood,	Do.
	0·025		Slight odour, . .	Do.
	0·05		Very faint odour, .	Do.
Sulphite of soda,	0·01	Between 50 and 60.	Slight odour, . .	Do.
	0·025		Do., . . .	Do.
	0·05		Do., . .	Do.

Substance used.	Odour on Tenth Day.	HS.
Carbolic acid, . .	Slightly putrescent warm blood, Do. do., . Spicy odour, ...	Trace. Distinct. Large.
Cresylic acid, . .	Warm stale blood, . . . Sour odour mixed with cresylic acid, ... Fœtid HS odour, . . .	Distinct. Do. Very large.
Hydrochloric acid, . (Sp. gr. 1·03.)		
Nitric acid, . . (Sp. gr. 1·08.)	Mild spicy odour, . . . Strong spicy odour, . . . Peculiar faint spicy odour, . .	Large. Do. Little.
Sulphuric acid, .		
M'Dougall's powder,	Slight odour of carbolic acid, . Putrescent odour of carbolic acid, Sulphuretted hydrogen, . .	Trace. Distinct. Very very large.
Heavy oil of tar, . (Soda solution.)	Slight odour of warm stale blood, Strong odour of warm stale blood, Tar and stale blood odour, .	None. Do. Large.
Heavy oil of tar, . (Water solution.)	Sour warm stale blood odour, . Sour sewage odour, . . Odour of warm stale blood, . . Warm stale blood odour, . . The same, but slightly putrescent, The same, putrescent odour mixed with that of tar, . . .	None. Distinct. Large. None. A little. Do.
Sulphate of alumina and ammonia, . (Alum.)	Warm stale blood odour, . . Putrescent odour, . . . Sour putrescent warm stale blood,	Trace. Distinct. Very large.
Bichromate of potash,	Slight garlic odour, . . . Strong sour spicy odour, . . Do. do., . .	None. Do. Do.
Chloride of aluminum,	—— Sour warm blood odour, . . Sour odour, ...	—— A little. Distinct.
Chloride of lime, .	Sour warm blood odour, . . Sour odour, ... Sour fishy odour, . . .	Slight. Distinct. Do.
Sulphite of soda, .	Farmyard manure, . . . Sour warm stale blood, . . Fœtid warm blood odour, . .	Distinct. Very large. Do.

In this series of experiments, where sulphuretted hydrogen and smell are chiefly considered, carbolic acid seems to take precedence of cresylic, when there are large quantities used, but the cresylic has certainly the advantage with small quantities.

Another curious result frequently before found perplexing is made here clear. The greater the amount of these acids used, the greater the amount of sulphuretted hydrogen when there is much water. They appear to oxidize at the expense of sulphur and compounds. If so, this may be the real secret of their antiseptic power, that the moment they touch such compounds, they put the molecules in a state of tension which prevents the ordinary decomposition, but in time and under water they produce another. They must be used with discrimination.

Hydrochloric and sulphuric acids failed; they seem to enter into combinations early, and to lose their character.

Nitric acid, on the contrary, stands very high.

Bichromate of potash also stands remarkably high. So far as sulphuretted hydrogen goes, it is really the first, and the smaller quantity as good as the larger.

The soluble matter of the heavy oil of tar in soda, which is equal to carbolic and cresylic acid in soda, produced least alteration with 1 per cent., but if 5 was used, a change was produced. The same remarks will hold good here as were made on the tar acids.

The watery solution of heavy oil of tar was not so efficient as the soda solution.

Chloride of lime stands well if too much is not used. Here we are again reminded of the evil of an excess, just as we were reminded of it when using chloride of zinc, where that most efficient disinfectant was made to stand as the very lowest in the scale in some circumstances.

I remember going with Mr. Ellerman to try his fluid, which was at that time chloride of iron only. It was poured on some very disagreeable substances in a town's yard in Manchester, but at the moment the disinfectant touched them, the smell became overpowering. Mr. Ellerman was much disconcerted. The secret is, that strong acid substances must not be used. Sulphite of soda turns out well until the sulphurous acid begins to decompose. A similar thing occurs with all sulphates and sulphites as well as M'Dougall's powder.

DEODORIZING, OR THE REMOVAL OF SMELLS, AND THE RELATIVE VALUES OF DIFFERENT DISINFECTANTS FOR THAT PURPOSE.

A bottle of blood freed from clot, treated with $\frac{1}{1000}$ of its weight of sulphite of soda, and diluted with twice its volume of water, having become putrid, was considered suitable for the purpose. Five bottles, which constituted the first series, containing each 100 c. c. of this matter, were treated with perchloride of iron, chloride of zinc, M'Dougall's powder, cresylic acid, and carbolic acid. The second series contained chloride of zinc, common salt, perchloride of iron, M'Dougall's powder, cresylic acid, and chloride of lime. The disinfectant was in each case added until the disagreeable smell was removed; the liquid was then distilled, and the quantity of permanganate of potash requisite to colour the distillate pink, was taken as the relative quantity of organic matter present. In the liquid distilled from the cresylic and carbolic alcohols, this test is not of any value, because the quantity of these substances which distil over themselves decolorize the permanganate. The accompanying table shows the results obtained, though in truth they are of themselves not worth much; this much, however, was determined by them, that cresylic acid is more powerful than the phenic or carbolic, and a mixture of it with sulphite of soda, better than either substance by itself. Large quantities of perchloride of iron, and the chlorides of zinc and sodium, failed to remove all smell, though the smell remaining was not that of putrid matter. A third series of experiments, considered an improvement on those just described, was carried out: 10 grammes each of the following substances were added to 100 c. c. of a putrid mixture of blood and two parts water; the mixture was then distilled, and the distillate was tested.

First Series of Experiments.

Disinfectants used.	Quantity required to take away the putrid smell.	HS.	Smell of the Distillate.
	Grammes.		
Cresylic alcohol or acid,	3	None, . .	Like fresh blood.
Carbolic do., . .	5	None, . .	Faint fatty smell mixed with that of the acid.
Perchloride of iron, .	12·25	None, . .	Like acroleine.
Chloride of zinc, .	15	Faint shade of brown.	Fatty smell.
M'Dougall's powder,	10	None, . .	Faint fatty smell.

Second Series.

Disinfectants used.	Quantity required to take away the putrid smell.	HS.	Smell of the Distillate.
	Grammes.		
Cresylic acid, . .	3	None, . .	Faint smell of animal oil.
Chloride of lime, .	7·5	None, . .	Smell like burnt horn.
Perchloride of iron, .	12·25	None, .	Smell like cow dung.
M'Dougall's powder,	10	None, . .	Smell like sewage.
Chloride of zinc, .	40	Faintly brown,	Very bad smell.
Common salt, . .	32	Faintly brown,	Very bad smell.
Cresylic acid and sulphite of soda.	2 of the cresylic acid; about 10 grammes of sulphite of soda.	None, . .	Fatty smell only.

Third Series of Experiments.

Disinfectants used, in the proportion of 10 grammes to 100 cubic centimetres of putrid matter.	HS.	Smell of the distillate.
Perchloride of iron, .	None, . .	Bad.
Chloride of lime, . .	None, . .	Pungent smell from a peculiar compound formed from the chloride of lime and ammonia; putridity gone.
M'Dougall's powder, .	None, . .	Bad.
Common salt, . . .	Light brown,	Bad.
Chloride of zinc, . .	None, . .	Disgusting.

Permanganate of potash, Condy's fluid, completely removes the smell at once.

Peroxide of hydrogen removes all the unpleasant smell, and adds a very agreeable scent.

From these experiments it is clear that even the most powerful antiseptics are far from being well fitted for removing putrid smells, when added in a strong state. Acids and acid metallic salts, such as chlorides of zinc and iron, send out a very disagreeable fatty acid, which seems to be the same that comes over with ammonia when the putrid matter is distilled. For this reason, chemicals such as these ought never to be poured on strong or slightly diluted putrid matter, in order to produce an immediate effect. They do, however, produce an effect afterwards. Common salt stands low here.

Cresylic and carbolic acids have no violent effect in sending out fumes, and here they stand among the best; better when mixed with sulphite of soda. Chlorine is very powerful; it destroys. It is eighteen years since I first tried a mixture of sulphite of soda and carbolic acid, and found that with one only complete disinfection could not be obtained. (Mr. Daniel Stone informed me that he used the two mixed as antiseptics before that time.) The result was the disinfecting powder, the character of which Mr. M'Dougall developed with great fulness, whilst I entirely left it. It is now made by many. It is easy to surpass such a mixture in any one of its qualities separately by some substance, but to surpass it in all, if more carbolic acid were in it, would require more than one, always supposing much water not to be present. On account of this small amount of carbolic acid, it is not put in the list of substances for fumigation and prevention of cattle disease. Its most fitting use is for preventing decomposition in manures. I speak of some time ago. I am told that more carbolic acid has been used since.

Chloride of iron tells here much better than chloride of zinc. I think this must depend on the state of saturation.

Chloride of lime acted better than any of the salts here given. It has many excellent qualities; it never gives out a foul smell under any circumstances, and may be used either on solid or watery impurities. The peculiar pungent smell spoken of as given out by it, comes from the destruction of the ammonia. This salt is elsewhere mentioned. Common salt has little power in removing putrid matter; its influence is colytic only.

Of these substances, I would of course prefer peroxide of hydrogen, if it were not out of the question as regards price, next permanganate of potash, for removing the smell; but it would be needful afterwards to add another agent to keep the putrefaction from returning.

In cowhouses, and even in families, these last two substances are expensive, and in the first not even to be thought of. What would we choose next? To remove a smell rapidly, chloride of lime is decidedly the most ready. People cannot well have every disinfectant at their disposal; and are they to use perchloride of iron only, which here comes out so well? If the prevention of decomposition were all that was wanted, this might be done, although it is by no means pleasant to cover the floor of cowhouses with liquids when they are already too wet; but the fact that the iron salt is not volatile, and does not act on the air, is a decided objection to its sole use. The tar acids by themselves seem best here also.

By the mixture of sulphite and tar acids we obviate the objection, but we, again, are subject to the formation of sulphuretted hydrogen if we allow the presence of much water.

We see then that it is a very complicated problem. Disinfection is not a magic act performed by a small piece of some substance which removes all evils at once. There are many evils in various conditions, and each must be attacked in its own peculiar mode. People must use their reason.

Additional Experiments on a Larger Scale.

Additional experiments were made on disinfection on a larger scale. Boxes containing each a hundredweight of human excrement, were kept in a warm building, and treated with

Carbolic acid,
Cresylic acid,
Common salt,
Chloride of zinc,
Perchloride of iron,
Chloride of aluminum,
A mixture of equal parts of cresylic acid and sulphite of soda,
Heavy oil of tar,
M'Dougall's powder.

A change was first noticed in the matter on the seventh day after adding the disinfectants, in the case of the first six boxes; the others were first looked at on the tenth day.

These experiments were made at the Eureka Manure Company at Hyde, where a peculiar mode of collecting the refuse of the town was adopted. I am indebted to Mr. Southwood, the manager, for making them.

The remarkable power of common salt is to be observed here:—

	On the 7th day.	On the 17th day.	On the 27th day.	On the 34th day.
Carbolic acid, . . . Quantity used, 2 oz. by measure.	No decomposition. A sickly smell.	As before.	Fungoid growth on the surface; no sulphuretted hydrogen, and no ammonia given off.	Not much sulphuretted hydrogen, but ammonia is evolved.
Cresylic acid, . Quantity 2 oz. by measure.	The same.	Decomposition commencing.	Fungoid growth. A little ammonia and sulphuretted hydrogen.	Ammonia and a little sulphuretted hydrogen evolved.
Common salt, . . . 2 oz. by weight.	Very little decomposition and a slight smell.	Decomposing slowly; a slight smell of sulphuretted hydrogen.	Fungoid growth. A little gas evolved. No ammonia or sulphuretted hydrogen.	Ammonia evolved, but no sulphuretted hydrogen.
Chloride of zinc, . . . 8 oz. by measure of a 50 per cent. solution.	Decomposition and a little smell.	Little decomposition, and the peculiar sour smell noticed when putrid blood was treated with chloride of zinc or iron.	No sulphuretted hydrogen, a little ammonia.	Not altered.
Perchloride of iron, . . 8 oz. by measure of a solution containing 20 per cent.	Decomposition and a stronger smell.	Black colour from sulphide of iron; the same peculiar smell.	No sulphuretted hydrogen, a little ammonia.	Ammonia and very much sulphuretted hydrogen evolved.
M'Dougall's Powder, 1 lb.	Decomposition and ammoniacal smell.	Fungoid growth on the surface. No sickly smell, a little ammonia disengaged.	Fungoid growth. Much gas evolved. Sulphuretted hydrogen, but no ammonia.	Much ammonia and sulphuretted hydrogen.
	On the 10th day.	On the 17th day.		
Chloride of aluminum, . 4 oz. measure of a 50 per cent. solution.	Decomposition and very bad smell. Fungoid growth.	Very much ammonia and sulphuretted hydrogen.		
Heavy oil of tar, 2 fluid ounces.	Fungoid growth. Tarry smell. Sulphuretted—much gas evolved.	Much sulphuretted hydrogen and ammonia.		
Sulphite of soda and cresylic acid, . . . 3 oz. of a mixture with water, containing one-fifth of each substance.	Fungoid growth. Rather a sickly smell. Sulphuretted hydrogen evolved.	The same as above.		

Carbolic acid comes out best here. It is much superior to tar. Common salt looks well. An addition was made to the common salt at Hyde. That was not examined, as it was the manager's secret.

VOLATILE OILS AND PERFUMES AS DISINFECTANTS.

Perfumery has been the mode adopted from the earliest times to destroy infection. The reason lies in great depths of horror, viz., in the fact that men have been able to smell some of the diseases they wished to avoid. Perhaps every disease has its odour; even the healthiest person has one, which warm weather and close rooms readily discover; a diseased person has another, and many diseases cause a modification. Men have tried to sink the smell beneath a perfume, as well as to destroy it, and they have done both to some extent. The history of perfumes is a history of luxury and extravagance; and it cannot be denied that in a country where washing is rare the excess of perfumes is the noticeable although imperfect growth of cleanliness and good taste. In preventing black death the medical faculty of Paris in its counsels, quoted by Hecker, says—" Every one of you should protect himself from the air, and as well before as after the rain kindle a large fire of vine wood, green laurel, or other green wood; wormwood and chamomile should also be burnt in great quantity in the market-places, in other densely inhabited localities, and in the houses." The use of incense is mentioned frequently in the Books of Moses; fragrants were equally important in Egypt; the Greeks had a business in unguents and scents more important proportionally than ours, and the baths of the Romans were scented to a height of luxury that we must wonder at without imitation. Although disinfection was one of the objects it was not the sole. Odours take possession of an organ for themselves in animals, and to this they can always apply—

giving pain or pleasure, as well as contributing useful knowledge. Some will say that the pleasure is more important than the use, but on this Goethe must be consulted. He says, "Let us cultivate the beautiful, the useful takes care of itself." Mahomet was fond of perfumes; all the East loves them, and if we read the Arabian Nights we see that they became a passion with many. Moore very rightly brings them forward as a Persian mode of comparing the excellence of Paradise:—

> "To thee, sweet Eden! how dark and how sad
> Are the diamond turrets of Shadukiam,
> And the fragrant bowers of Amberabad!"—

these places being themselves creations of a luxurious imagination. Shadukiam, we are told, only means the country of delight. The Peri in taking farewell of the earth thinks only of the odours and the flowers. But Moore's idea was only borrowed. In the 45th Psalm we read, "All thy garments smell of myrrh, aloes, and cassia, out of the ivory palaces, by which they have made thee glad."

Why should a book on disinfection speak of such things? Time only prevents me saying more. It is good for us to connect our daily life with the history and strivings of our race. We receive warning and guidance. Looking on the doings of early times, it was extremely interesting to know how far men were right when they sought the aid of perfumes in the time of plagues. I therefore attempted to compare them with each other, and with our stronger disinfectants. All the agents mentioned here affect the substances in the atmosphere; they are fumigatory, acting by evaporating and seeking their prey in the air as well as on the spot where they are laid. This table will give us a fair comparison of their strength. Knowledge concerning them will grow by degrees. These substances protect; but they are weak, and are not to be compared to some which we now possess. Some of those never seem to kill even mould infallibly; the only question is how much can we endure, and how much must we take so as not to injure our own lives when we destroy the lives of those existences or prevent those activities which produce the disease?

In this class there is no difficulty or hesitation; every experiment is clear and distinct, and can be repeated easily. The object of the inquiry was to find those substances which, in a volatile condition, prevented putrefaction in an atmosphere which could easily be breathed. It was made by pouring into bottles of about 900 cubic centimeters volume —equal to about a pint and a half—about five drops of these volatile substances. Over this was suspended a piece of meat about three inches in length and about three-fourths of an inch in diameter. It was not brought in contact with the substance; the cork was put loosely in the bottle, which was opened generally every day, no attempt being made to keep out the atmosphere.

These experiments are very satisfactory, and if our theories of floating active organic substances be correct, the question as to the possibility of their destruction or infection in this manner seems to be settled, so far as this treatment goes. But to this also something is wanting. It is desired to know at what distance that flesh may be suspended with safety, as it was clear, in all cases where there was visible action on the meat, that it was most violent at the lowest part, where it was nearer the liquid. In the best case of preservation there seemed no difference, as the flesh was unaltered throughout, to all appearance, except where difference of colour, as already mentioned, was produced. The slightest alteration took place with cresylic acid; the meat seemed to be quite suited to excite the appetite. It seemed slightly cooked. It was overdosed, however, even with this small quantity. When aniline and coal naphtha were used, the pieces of meat were perfectly preserved from putrefaction, but had an appearance scarcely resembling flesh.

Results of Experiments made in order to ascertain the influence of Volatile Substances in preventing Putrefaction.

The Experiments were made on pieces of Lean Flesh (Beef), all cut from the same piece. The beef was exposed to the Vapour of the various Substances by suspending it in bottles at the bottom of which a small quantity of the substance was placed. The smell in all cases so that one could easily breathe it, with Phosphorus excepted.

	1865.					1866.
	Nov. 29th, after 6 days.	Dec. 5th, after 12 days.	Dec. 10th, after 17 days.	Dec. 15th, after 22 days.	Dec. 26th, after 33 days.	Jan. 13th, after 51 days.
Flesh—alone, . . .	Putrid and whitened.					
With phosphorus in water,	Not had, but whitened.	Bad smell.	Flesh beginning to be bad, although the bottle is full of ozone.	Diminishing in size: black.	Very small, black and hard; watery solution clear, containing acid and ammonia.	
Naphthaline, . .	Rather bad, not whitened.					
Cresylic, . { alcohol / acid . }	Very sweet; scarcely altered in colour.	Quite sweet: slightly whitened.	As on 5th Dec.	As on 5th Dec.	Still fresh.	Quite fresh.
Carbolic (phenic) { alcohol / acid . }	Fresh, a little whitened.	Fresh; a little darkened.	As on 5th Dec.	More smell than cresylic acid.	Still fresh.	Quite fresh.
Coal naphtha, . .	Fresh; a trace of discoloration.	Sweet, and red natural colour; slight sliminess helow where nearest the naphtha.	As on 5th Dec.; sliminess increased.	No had smell, but slimy and red, as if disintegrating.	Decomposing; soft and oily-looking.	

	1865.					1866.
	Nov. 29th, after 6 days.	Dec. 5th, after 12 days.	Dec. 10th, after 17 days.	Dec. 15th, after 22 days.	Dec. 26th, after 33 days.	Jan. 13th, after 51 days.
Canadian petroleum (crude)	Putrid; colour darkened.					
Aniline,	Uncertain; slight whitening.	No putridity; colour dark, not pleasant to look at; smell of aniline, also unpleasant.	As on 5th Dec.	As on 5th Dec.; unpleasant smell.	Not putrid, soft and deliquescent.	Not putrid, soft and deliquescent.
Nitro-benzole,	Sweet; very slightly coloured.	Bad, black.				
Turpentine,	Slight decay; colour good, especially below, nearest turpentine.					
Creasote,	Very sweet; slightly darkened on some places	Fresh, dark.	Blacker.	More blackening	Fresh.	Still fresh, but a little darkened.
Wood naphtha,	Fresh; very much whitened.	No putridity; flesh very light and dry.	Whiter, but otherwise as on 5th Dec.	As on 10th Dec.	Fresh and white.	Fresh and white.
Pyroligneous acid,	Sweet; very white.	Fresh, white.	As on 5th Dec.	Mouldy, but no putrid smell.		
Acetic acid (pure),	No smell; colour dark.	Fresh, but very dark colour.	Very black.	Very black, slimy below; pleasant acid smell.	As on 15th Dec.	Not putrid, but unpleasant to look at.
Camphor,	Bad; slightly darkened.					
Oil of cinnamon,	Rather bad; whitened.					
Oil of mustard,	Fresh; colour greyish white.	Fresh; very white.	Fresh; colour greenish yellow.	As on 10th Dec.	Fresh.	Fresh.
Oil of bergamot,	Slight decay; slight darkening.					
Oil of bitter almonds,	Fresh; good colour.	Fresh.	Fresh.	Fresh.	Fresh.	Fresh.

	1865.					1866.
	Nov. 29th, after 6 days.	Dec. 5th, after 12 days.	Dec. 10th, after 17 days.	Dec. 15th, after 22 days.	Dec. 26th, after 33 days.	Jan. 13th, after 51 days.
Oil of pepper,	Beginning to decay; a little whitened.	Bad; slimy, .	Like bad fish.			
Oil of cumin, . .	Fresh; colour good.	Bad; slimy.				
Oil of lavender, .	Fresh; colour good.	....	Bad.			
Oil of hops,	Fresh; colour a little dark.	Bad.				
Oil of thyme, . .	Bad; colour lightened; surface soft.					
Oil of rue, . .	Good; colour a little light(bad, smell of rue)	Not putrid, but slimy.	Dreadfully blotched.			
Oil of rosemary,	Fresh; colour good, a little light.	Going bad.				
Oil of juniper, .	Very fresh; colour good.	Going bad.				
Oil of orange peel,	Beginning to decay; colour fair.					
Oil of peppermint,	Very fresh; colour pretty good.	Not very bad smell, but very slimy.				
Oil of lemons, .	Bad; colour bad; surface becoming soft.					
Oil of valerian, . .	Doubtful; a little dark.	No bad smell, but slimy.				
Oil of aniseed, .	Bad; colour not much changed.	Going bad.				
Fuşel oil (amylic ether),	Sweet; very slightly whitened.	Sweet; good colour.	As on 5th Dec.	As on 5th Dec.	As before.	Still Fresh.
Essence of pine apples (butyric ether), .	Sweet; slightly whitened.	Fresh, a little dark.	As on 5th Dec.	Mouldy, but no bad smell.		
Gum asafœtida,	Not so putrid as flesh alone; colour not bad.					

Comparative Order, and Position in each Order, which the following Substances occupy in respect to their power of Preserving Meat. The numbers give the order but not the proportionate value.

1	2.	3.	4.	5.	6.	7.	8.	9.	10.
Cresylic acid. Fusel oil.	Carbolic acid. Creasote.	Oil of mustard.	Wood naphtha. Oil of bitter almonds.	Acetic acid. Pyroligneous acid. Ess. of pine apples.	Coal naphtha.		Oil of juniper. Aniline. Oil of peppermint. Oil of rue.	Turpentine. Oil of lavender. Oil of valerian. Phosphorus and water. Oil of cumin. Oil of rosemary. Oil of hops.	Oil of cinnamon. Oil of thyme. Oil of orange peel. Oil of bergamot. Oil of pepper. Napthaline nitro-benzole, camphor. Oil of lemons. Oil of aniseed. Gum asafœtida. Crude Canadian petroleum.
	Preserve equally long with the first, but colour not so good.								

The result of these experiments is, that methylic alcohol or wood spirit, carbolic acid, cresylic acid, oil of mustard, creasote, oil of bitter almonds, and fusel oil, preserve the meat fresh, that is, with a pleasant odour; the last two are the most poisonous. Aniline prevents true putrefaction, or that of the usual kind, but seems to begin another. Acetic acid of the strength used seems to have an action too powerful. Several preserve for some days, and retire from the conflict. Time seems to have no influence on some of them, but the best of the pieces are preserved mainly by one class of substances only, and these turn out to be alcohols. Mustard oil preserves well, but it threatens to harden the flesh, and the colour is much changed. Oil of bitter almonds seems to preserve well, but the flesh soon loses its firmness, whilst, in the case of the alcohols, there seems to be no drawback. It is curious indeed if this should turn out to be a property of this series of bodies. The composition is here added in order to show that they stand to each other as homologous compounds.

In the natural order, so to speak, the cresylic and carbolic compounds would be called acids, because acidity is the more sensible quality; but by their composition they take the place of alcohols. We have then disinfectants which form a chemical series:—

Alcohol—

Methylic, . .	$C_2 H_4 O_2$, or $C H_4 O$
Ethylic, . .	$C_4 H_6 O_2$, or $C_2 H_6 O$
Amylic, . .	$C_{10} H_{12} O_2$, or $C_5 H_{12} O$
Carbolic (phenylic), .	$C_{12} H_6 O_2$, or $C_6 H_6 O$
Cresylic, . .	$C_{14} H_8 O_2$, or $C_7 H_8 O$

and wood creasote, which much resembles the latter two.

The exact order of these substances as disinfectants had not been made out, but it seems to have some relation to the order now given. Cresylic alcohol seems to preserve meat best under certain conditions, to be pointed out afterwards. Amylic preserves remarkably well, but the two evidently act in a different way. I am not here preserving meat for food; I am speaking of the preservation of animal substances, or rather arresting the activity of impurities first, or, in other words, of disinfection. The use of amylic alcohol in the above method as a preserver of flesh to be eaten is impossible, as it is poisonous, as the use of much of the others would be. Dec. 1868—the mustard specimen still unaltered.

These vapours completely prevent the action of the air, and of the bodies, organic and organized, that the air may bring with them. If the diseases attacking us or our cattle resemble such bodies, they will also be rendered innocent by the use of these vapours.

A very serious question, however, arises: If the disease is slain, is the living being preserved? Tho action on living creatures is more difficult in many cases than that on dead. It is more difficult to act by oxidizers and some other agents on fresh meat than on corrupted, although, if we consider the blood as living and the skin as dead, the reverse is the case.

However, the practical question is, can the larger animals live in an atmosphere so filled with these vapours that meat will not decompose? If this is answered in the affirmative a great deal is gained. I may say all is gained. It may probably turn out that the resistance will be sufficient for some of the putrid matter or the germs, and in this case the disease they brought would be warded off, whilst it might be insufficient in other more violent cases. This is the point to be practically ascertained. We must remember, however, that it is simply a question of strength,—which will bear most, the disease or the diseased. These colytic agents are so powerful that they can arrest the life as well as the corruption. Experience however is in favour of the vigour of life. I have heard of no one being injured by breathing air scented by carbolic and cresylic acids all day for a long time together, and I have myself breathed them night and day in a mild state. Very strong they must never be breathed, and never touched as liquids, as, although mild at first to the taste, they remove the skin. The above experiments were all made at a temperature varying with the season.

I am sorry I have not yet obtained the extreme limits or the smallest amount of cresylic vapour for a certain quantity of material or a given volume of air.

Our ancient and admired disinfectants must now learn to retire on great emergencies. Rue, rosemary, lavender, and pennyroyal may still be used to prevent attacks on our clothes, or to scent the wardrobes; but when the preservation of matter for a long time is the question, they must be left aside. They are like the mild precautions of a time of peace.

Those substances which have preserved the flesh and not destroyed the fibre, will preserve also the putrescible matter in manure, and prevent it sending impurities into the air. This is ascertained beyond doubt. The vapour at a low temperature destroys the substances causing putrefaction. That also is ascertained. We require only to use it until we ascertain if it will destroy every kind of substance that causes every kind of putrefaction. If every kind is not destroyed, how many kinds? Probably the pus, germs, or ferment will be preserved as soon as the vapour touches it, and will remain as unchanged and as innocent as a mummy until washed into the earth, and destroyed by air, water, and vegetation.

THE EFFICIENCY OF STRONG GASES AND VOLATILE SUBSTANCES IN PREVENTING PUTREFACTION.

In order to gain information on this point, pieces of meat about an inch broad and thick, and about three inches long, were placed in bottles containing the following gaseous and volatile bodies :—

Chlorine.	Sulphurous acid.
Bromine.	Protoxide of nitrogen.
Iodine.	1st Nitrous fumes.
Hydrochloric acid.	2d Nitrous fumes.
Peroxide of hydrogen.	Ether.
Ammonia.	Heavy oil of tar.
Carbonic acid.	M'Dougall's powder.

The chlorine was prepared from chlorate of potash and hydrochloric acid, and was therefore a mixed gas; the sulphurous acid from sulphite of soda and sulphuric acid; the nitrous acid from copper and strong nitric acid; the 2d nitrous gas from copper and weak nitric acid; the hydrochloric acid from common salt and sulphuric acid; the ammonia from lime and sulphate of ammonia; and the protoxide of nitrogen from nitrate of ammonia.

The gases were passed into the bottles for a considerable time; these were then closed up by corks covered with paraffin, the meat being suspended inside by a string. They were kept in the laboratory at a temperature of from 60° to 70° Fah. (15·5° to 21° C.)

Table showing the Effects of Gases, etc., on Flesh.

	Time elapsed since the fastening up of the Bottles.	
	7 Days.	28 Days.
Chlorine, . . .	Bleached and hardened a little. Smelt only slightly of chlorine. Quite good.	In appearance Unchauged; meat red inside; bleached on the surface.
Bromine, . . .	Whitish yellow in colour. Slight smell of hydrobromic acid. Quite good.	Slightly pinkish in colour; faint smell of hydrohromic acid. Quite good.
Iodine, ...	Dark yellow; dried. A little iodine in the bottle. Quite good.	Orange red; white inside; no smell of iodine. Quite good.
Hydrochloric acid, .	Darkened; no smell of hydrochloric acid. Quite good.	Unchanged.
Ammonia, . . .	Darkened; the meat smelt of ammonia, hut the hottle did not. Quite good.	Unchanged.
Protoxide of nitrogen, .	Sweet fresh smell; a little lighter in colour. Quite good.	Meat had; lighter in colour.
Nitrous acid, . . .	Light yellow, from a little peroxide. Quite good. Nitrous acid still in the bottle.	Unchanged.
2d Nitrous gas, . .	Light yellow and dried. No red fumes in the hottle. Quite good.	Unchanged.
Carhonic acid, . .	Smell had and meat slimy.	
Sulphurous acid, . .	Not quite so red. Quite good, smelling of sulphurous acid.	Unnatural pink colour; smell of sulphurous acid. Quite good.
Ether, ...	Not quite so red, but quite good.	Unchanged; faint ether smell.
Heavy oil of tar, . .	Putrid and slimy.	
Peroxide of hydrogen, .	Putrid, slimy, and mouldy.	
M'Dougall's powder, .	Putrid and slimy.	

In these experiments we find that the powerful gases described are absorbed by the meat, and probably as in the presence of the vapours of phosphorus, ammoniacal salts are formed, and, in the presence of water, solutions of certain portions of the nutritive matter, as in Liebig's extract of flesh. It seems to me, however, that a greater amount of gas is required in their case than in the case of the organic acids in No. 1. The gas required to be stronger, by which words is meant that it had more effect on the senses. I believe also that in actual weight the amount was greater; but this has not been proved.

The ether scarcely belongs to this set, but it is interesting to observe its effect, showing that the alcoholic series is not the only one which has a disinfecting power. It may be that it is the base which has the power, and that the hydrates only share it.

All the strong acids completely destroy the natural appearance of the flesh, and render it very unpleasant to the sight; but as preventives of putrefaction they are perfect. The less unpleasant specimen was that in sulphurous acid; it was, however, of unfleshlike pink. Too much was used, as the very successful use of the bisulphite of lime now shows.

Nitric acid or any nitrous gases must be avoided where animals are. The senses do not perceive all the dangers of these fumes, and men leave them quite well to become ill in a few hours, and not to recover. Muriatic and sulphuric acids act otherwise. The senses are alarmed, and avoid them even where there is not sufficient to bring danger to the health,—certainly none immediately, and even when there is none prospectively, so far as we know, if not continued in.

Protoxide of nitrogen, of all substances tried, allowed mould to come most rapidly, and the quality was peculiar. It seemed to invite the mould. In all cases of mould the beginning was nearest to the cork, evidently finding entrance by the air.

M'Dougall's powder was tried here simply to see if it gave off carbolic acid enough to prevent putrefaction of meat; it was found not to do so.

FUMIGATION.

As this is so often spoken of, although not by the name, only a few remarks are here made. See the Gases and Vapours.

We have spoken of antiseptic bodies that crumple up organic matter, and cause it to lose one of its most characteristic qualities, putrescibility. When we apply antiseptics to these minute bodies in the air, the result will be the same as on a larger scale to giant growths. This then is the whole explanation of fumigants; they mix with air, enter into every corner of a room, and attack every atom floating free, treating it as they would a piece of meat, which we know may be preserved for ages. Disinfection by fumigation cannot then be said to be supported by a mere theory, it is an action as certain as salting meat, but more effective, because we can use agents more powerful than salt. We have here the explanation of all the strivings of those men who have used vinegar, camphor, and perfumes, aloes, myrrh, and cassia, as well as chlorine, muriatic, sulphurous, and carbolic acids.

The truest antiseptics are volatile organic bodies. They do not destroy, they preserve. They prevent action; and how distinct are the gradations of this influence! If we inhale ether we lose one of the most characterizing portions of animal life—the knowledge of an external world. We lose sensation; at a later stage we lose the action of mind. If we take alcohol, we have the oxidation disturbed, and the power of exertion, whilst less carbonic acid is given out. This is at least so in many cases, as Dr. Edward Smith has shown. But when we use carbolic acid as a strong liquid, we have the chemical action of the muscular fibre itself stopt. We can occasionally observe numerous stations between these points. These agents produce in succession drunkenness, anæsthesia, and destruction of the motion of life, ending in the suppression even of those movements needful for decay. It seems rational to treat the agents of disease existing in the air exactly as the Egyptians treated their dead, by the use of antiseptics, and unquestionably, if organisms infect the air, they will die in the presence of these agents as animals or vegetables die, and be preserved as mummies are preserved, until washed into the soil. But if any one is afraid that the disease is only allayed by these means to burst out again, let him remove the disinfectants from the mummies, and he might almost as soon expect them to return to life.

THE ACTION OF AIR.

Air is well known to be one of the greatest disinfectants. If a room is unwholesome, or if it is close, let the air blow for some time into it, and it is pure. If the air blows violently over a district infected with disease, the disease is in many cases removed. It may be remarked that the mere filling of a room with fresh air is not sufficient to render it pure; it seems quite necessary that the air should play about, and that the room should be filled and refilled frequently. If the whole oxygen of the air acted with equal power one would scarcely expect this result. It is explained, however, by supposing that one portion, and that very small, of the oxygen of the atmosphere is very active, and it is sufficient if even a very small portion of that comes in contact with the surfaces in the room which require to be cleansed, by having that organic matter with which they become plastered oxidised and destroyed; an equally efficient destruction of impurity is effected on furniture by the ordinary process of rubbing, but cannot be performed upon walls, books, and pictures, and in various corners not easily accessible. The effect can in part be explained by supposing the unwholesome matter to be in the form of fine particles, germs, or otherwise, which would require to be removed as dust would be, and which the rapid and mechanical action of the wind would gradually sweep away. The accumulation of carbouic acid from breathing, and from the combustion of gas and candles in a room, is prejudicial; but the products are very rapidly removed, simply by refilling the room once with fresh air. It is not so with that matter which may be called organic. Although, as a geueral rule, this method of cleaning a house by sweeping, washing, and abundant airing, is decidedly the wholesomest and best, and may be considered to be the standard method, there are cases in which it proves itself insufficient, when, for example, the external air is unwholesome, either by being infected by the emanations from marshes, or, let us suppose, from air contaiuing germs capable of producing any other disease. The otherwise wholesome and refreshing entrance of air may bring in vapours or particles of a most deadly kind. In such cases it seems natural that the ancient practice of fumigation should be used, the only method by which these accompaniments of the air can be reached. If the air be really the vehicle of any disease, it seems natural to suppose that fumigation, or the use of gases or volatile substances, should be the only mode of effecting a cure, or, at least, a prevention, and until these opinions shall have been proved entirely futile it seems as if we should be compelled to resort to this practice. For these reasons it seemed to me rational to compare these experiments in which meat and blood are preserved fresh with the operation and prevention of cattle plague and similar diseases. These chemical agents which cause putrefaction in the one case will be destroyed by fumigation, and in the other those germs which cause the growth of fungoid substances are destroyed, or at least rendered incapable of taking root. If the germs which cause (if they do cause) plague are at all similar, they will be similarly affected. The experience of mankind is in favour of fumigation; it seems as if all that was required was a more complete method of effecting the object than has hitherto been found. Whether any substance of which we have now the command would be found complete in all cases, is to be tried.

OZONE.

Schönbein's singular discoveries and patient inquiries have had a great effect on our views of elementary substances, and even of matter itself, although he himself has mainly viewed the great part played by oxygen in nature. So difficult has he been to follow, that some have preferred to call him an enthusiast whom reason had ceased to guide; but where he has been he has left marks so clear that no man can doubt that he has made genuine voyages of discovery, although there may be still some uncertainty about the map to be drawn. The discovery of the action of powerful oxidizing agents in the air, whether to be called ozone or not, is a remarkable event. It was at once the experimental proof of the existence of influences which scientific men had been disposed to deny, because they could not see their possibility, and a beginning of new inquiries.

The test given by Schönbein for ozone has been iodide of potassium and starch. Ozone sets iodine free, and that body, with starch, forms a blue colour. When paper is soaked in the mixture it becomes an ozonometer, and the depth of the blue colour is a measure of the amount of ozone. Air, which is to the senses very pleasant, gives the blue colour; air of close places does not give it. Perhaps no one has watched the changes more carefully than Dr. Moffat of Hawarden, and his results certainly seem to indicate a very wholesome purifying oxidizing body in the air, as Schönbein explained it. For practical purposes, it matters little if this is pure ozone or only peroxide of hydrogen, or even an oxide of nitrogen, or other thing. Its existence does not seem to be an absolute proof of the wholesomeness of an atmosphere, but it seems to be found always in atmospheres proved to be wholesome. In a smoky town it is never found, although the atmosphere is invariably acid, and this seems to be a sufficient proof that mere acidity is not the cause of the phenomenon. But it has been said that it is nitrous acid before it is acted on by the sulphurous acid of smoky towns; if so, the test for the acid is much more difficult to be obtained than that for ozone. The so-called ozone indications are found on the sea-shore in ten minutes in a fine breeze; but for acid by no means without great labour. Peroxide of hydrogen gives the same indications, and even the oxygen coming from it, and the air above the liquid, act in a similar way. May there not be peroxide of hydrogen in the atmosphere? has been asked. It is abundantly clear that there is a subtle something existing in the atmosphere. Half a mile from Manchester it is found in abundance: but let the wind blow at any speed it is never observed in the town. It must be removed from the air in a few seconds. I have tried for it daily for months together and have never found it in the town. Indeed, so subtle is it, that it seems to scent Manchester at a distance; it refuses to approach, as if the influences of the city were sufficiently powerful to pass out against a breeze, or to have planted themselves firmly enough on the surrounding land to affect the air in the immediate vicinity of the city. Messrs. Andrews and Tait have shown the relations of oxygen and ozone. Atmospheric ozone is not so clear.

It is absurd to speak of town air being unaffected by manufactures. I have explained to myself the results given, as I suppose others have done, by supposing the sulphurous acid to take up the active oxygen. At any rate, in cities producing much smoke we are deprived of this body—ozone. Is it for good or for evil? The answer is clear enough,—that it must be hurtful. But is this the only reply? The substances bringing this evil may also be bringing certain advantages.

The sulphurous acid of the coal smoke is disinfectant, but we know at least that it destroys the so-called ozone condition of the air; still, if good, it is so trifling that we hear of no disease which it drives from our towns, although it is probable that by a larger amount of sulphur some diseases might be removed. We lose the oxidizing influence of the strange new body, which again destroys the sulphurous acid, which is expected to disinfect, leaving chiefly sulphuric acid, a weaker disinfectant; the result then is, that we really lose one of the valuable qualities of the air, whilst we receive none sufficient to compensate for it, but, on the contrary, have dilute vitriol to breathe, so to speak. The mere smoke of coal, with its sulphur and carbon compounds, has always been allowed to go too free from accusation.

Ozone is said by Schönbein to be produced by the evaporation of turpentine and many oils, as well as by many organic substances, which are believed to be in a state of oxidation. Apparently, the filthiest places have the means within themselves of producing ozone and clearing the atmosphere of their own impurities. I do not pretend to have gone over the whole range of ozone literature for the purpose of this paper, and have no time to make references needful for an exact revision of the subject; but the action of turpentine, citron oil, and other volatile substances, could not be overlooked when they were supposed to be connected with oxidation,—a function of ozone. This oxidation seemed to be a clue to the facts and traditions regarding perfumes of all kinds, used in all ages to prevent disease, especially infectious, and to remove moths, mildews, and all those attacks to which clothes and food are subject. For this reason the following oils and volatile substances were tried. All who have read of ancient plagues will remember the frequent use of myrrh, camphor, vinegar, and numberless balsams and perfumes; and those who have attended to our own country habits will know of numerous other substances.

The result of the examination seems to be that these substances are antiseptic, but not to such a powerful degree as others to be mentioned; they are, however, agreeable at the same time, which is not the case with any of the most powerful antiseptics. Their constant use has no doubt a beneficial influence in cases where the evils to be avoided are not very great; but they have failed in bad cases, as we here find they fail to preserve the meat when the tar acids and similar substances showed no signs of failure. I look at their action as a proof of the great accuracy and the remarkable delicacy of observation to be found in popular beliefs. Ages of men with acute senses have been able to find the existence of qualities which we are apt at present to overlook, having an easier mode of observation in our hands, namely, chemical experiment, in which the senses being so much aided do not demand exalted delicacy.

It may be seen that few of the thirty-five substances hitherto tried in this way produced indications on ozone paper. Compare with Table following this.

None of those which can be received as perfumes, or even light oils, have produced sufficient vapour at the ordinary temperature to preserve, for a long time, meat standing immediately over them. Some, however, have preserved it longer than others. It was an interesting question, Did those which preserved it longest produce most ozone? It is quite clear that the amount of preservation was not in proportion to the amount of ozone. Turpentine is a bad preserver; oil of mustard produces an ozone, and is a very active preserver. Even oil of orange-peel, which, of all others, produces most ozone or active oxygen, is comparatively a bad preserver. Although not for this inquiry of practical value, it was interesting to inquire if, when no ozone was at all produced, some other influence affected the blueness of the starch paper. In the same bottles were put pieces of blue litmus paper, and after some days the result was observed. It will be seen that in five or six cases the blue had become red.[1] In fact, an acid was produced, and not only ozone. In one or two cases the paper may have appeared to be rather bleached, which may have indicated ozone; but in the most decided cases, such as the oil of orange-peel, the paper was first of an intense red, and afterwards white. In order to examine this more carefully, red papers were put in the same position, and in some cases a blue colour seems to have been produced. This certainly is against the exclusive ozone theory of these reactions. There is room for more inquiry here; but it seemed to me well to see if the ozone to be gained were really a great power or only a trifling one. I think that, so far as these oils are concerned, it is trifling at best, and non-existent in other cases.

[1] This Table is in the original report, but left out here.

EXPERIMENTS were made to ascertain if ozone was formed during the evaporation of the following substances, with the results marked opposite each ; the quantity of ozone formed is represented in arbitrary numbers, 1-10, according to the intensity of colour imparted to paper prepared with iodide of potassium and starch.

	After 18 Hours.	After 24 Hours.	After 48 Hours.	After 72 Hours.
Naphthaline, . . .	None.	None.	None.	None.
Cresylic acid, . .	Do.	Do.	2	2
Carbolic acid (pure), .	Do.	Do.	None.	1
Coal naphtha, . .	Do.	Do.	Do.	?
Canadian petroleum (crude),	Do.	Do.	Do.	1
Aniline, . . .	Do.	Do.	?	1
Nitro-benzole, . .	Do.	Do.	None.	None.
Turpentine, . . .	A little.	Increased.	7	9
Creasote, . . .	None.	None.	None.	None.
Wood naphtha, . .	Do.	Do.	Do.	Do.
Pyroligneous acid, . .	Do.	Do.	Do.	Do.
Acetic acid (pure), . .	Do.	Do.	Do.	Do.
Camphor, . . .	Do.	Do.	Do.	Do.
Oil of cinnamon, . .	Do.	Do.	1	1
Oil of mustard, . .	Do.	Do.	None.	None.
Oil of bergamot, . .	?	?	1	1
Oil of bitter almonds, .	None.	None.	None.	½
Oil of pepper, . .	Do.	Do.	1	1
Oil of cumin, . . .	Do.	Do.	2	2½
Oil of lavender, . .	Do.	Do.	2	2½
Oil of hops, . . .	Do.	Do.	None.	½
Oil of thyme, . .	Do.	Do.	Do.	1
Oil of rue, . . .	Do.	Do.	Do.	2
Oil of rosemary, . .	Do.	Do.	?	2
Oil of juniper, . .	Considerable.	Increased.	5	5
Oil of orange-peel, . .	Do.	Much colour.	9	10
Oil of peppermint, . .	None.	None.	None.	None.
Oil of lemons, . .	Do.	Do.	Do.	½
Oil of valerian, . .	Do.	Do.	Do.	None.
Oil of aniseed, . .	Do.	Do.	Do.	1
Fusel oil (amylic alcohol), .	Do.	Do.	Do.	None.
Ess. pine apple (butyric ether),	Do.	Do.	Do.	Do.
Gum asafœtida, . .	Do.	Do.	Do.	Do.

In air and water we have in reality the action of oxygen ; but we may have concentrated oxygen, and we may have oxygen in an active state. If concentrated oxygen is put into a vessel with blood, it is absorbed quietly, without true putrefaction and without any effervescence. It retards for a while the progress of putrefaction, but its ultimate effect is said to be rather to hasten it when contact with the air is renewed.

This examination is not completed. Active oxygen, or ozone, has a very distinct power in preventing putrefaction. If it is formed by the action of sulphuric acid upon permanganate of potash, the putrefaction is long delayed; but in order to succeed completely, it requires to be pretty well concentrated. How much must be present is not yet ascertained, but decidedly an amount inconveniently large in practice is required. When phosphorus is used to form ozone, putrefaction is completely prevented; but how much is owing to the active oxygen, and how much to the phosphoric vapour, remains a question. The mixture is so very powerful, that, in passing it through caoutchouc tubes, they were very rapidly eaten through. It is capable of destroying any organic substance which is put in connexion with it. Tried at one time in a solution of sugar, it was found that the colour was certainly removed and the sugar also. When the phosphoric vapours were removed, there was still active oxygen, which, however, had not these violent effects. In contact with flesh it will be seen from page 101 that this vapour prevents any putrefaction or fungus, attracts water in great abundance, and destroys the flesh, and that at the bottom of the bottle is found a mixture chiefly containing phosphate of ammonia (not carefully examined), whilst the flesh has been in a short time almost entirely consumed. The extraordinary power of this vapour in destroying organic matter must no doubt render it one of the best disinfectants; we can suppose neither germs nor decomposing organic bodies to remain unaffected in its presence. Whether it can be applied to a very great extent or not may be a question; and whether it is not accompanied with certain dangerous properties is also to be considered. We know that those who work with phosphorus are sometimes affected with a peculiar disease, which attacks the teeth and jaw-bone, apparently much in the same manner as the flesh in the experiment alluded to, for it seems not to have the power of attacking sound matter, but begins at decayed teeth, making its way to an unlimited extent into the bone. A large maker of matches in Germany, who employed about a thousand people, informed me that by taking care to employ none who had unsound teeth he was able entirely to prevent the disease from entering his workshop. Because of their activity I have been rather afraid of recommending these vapours, spoken of by Dr. Moffat with great praise, although he has used them to a large extent, I believe, and has found no evil effect from them. I have not used them for ventilation, and can only speak of the experience of others, which, however, has been on a scale sufficiently large to demand attention. I should rather refer to him for a practical method of treating large establishments with these vapours.

WATER.

Water is, next to air, the greatest disinfectant; soil combines both. Although water causes many unwholesome decompositions, it is that wherewith we wash, and no other disinfectant can take its place. We must "wash and be clean."

The importance of water has greatly obscured the cause of disinfection. Engineers have insisted on the removal of all refuse by floods only. They have been tied down to a mechanical mode of cleaning by their education. But disease comes in the midst of their enterprises and shows them ineffectual. Plagues are too subtle to be caught in all stages by the rough art of mechanicians. The invisible action of chemical agents is alone able to combat these invisible enemies; nevertheless the glories of water are more than this book can relate. The delights of bathing are best told by a Roman who well knew the luxury.

He is disposed to think of streams, of beautiful lakes, of fine days by the sea-side, of freshness after fatigue, of cleanness after dust and heat, and of indulgence in dreams of ease, which we in England enjoy more in the description than in the reality.

It is impossible to do justice to the use of water in this chapter. Washing and bathing are scarcely included by us in the word *disinfection*, although, strictly speaking, they ought to be; however, it is pedantic to follow out the reasoning so fully, and instead of vain attempts we shall leave Martial to describe the joys of a life in the water, and keep it as a bright distant point at which we must hopelessly aim :—

"To Oppian.

Bathe in Etruscan baths if you can,
Or you'll die without washing, Oppian.
Abano to the maidens rude
Will never do you half the good;
Nor Passer where the wells are hot,
Nor Sinuessa, softening spot;
Nor Anxur, proud of all its graces,
Nor Baiæ, prince of watering-places.
Somehow the weather 's always fine,
The light is long, and the day's decline
Is very slow, and 'going away'
Are words one never thinks to say.
Rocks with all beauties there abound,
Cut out of many a distant ground;
Warm, breathing onyx fat and fine,
And various-coloured serpentine.
If hot Laconian vapours please,
Here lie, though melting, at your ease;
Two streams supply you all you crave,
The Virgo and the Marcian wave,
Water so bright and clear and fair
You think no liquid can be there.
You 're not attending, Oppian,
You 'll die without once having washed, poor man."

ACTION OF WATER.

The action of water in removing deleterious substances is partly mechanical; it lifts or makes lighter particles not easily reached, and the impure matter is diffused through the liquid to be oxidized without necessarily evaporating. Without it, it seems impossible to produce absolute purity of surface in most cases. When it is saturated, however, it begins to give off vapours into the atmosphere, and, as water may be said to be equal to a porous body having an unlimited surface, its activity is very great. It absorbs oxygen rapidly, helps it to oxidize the organic matter, and send forth carbonic acid, and along with it many vapours into the atmosphere, and intensifies the operation to such an extent that bodies which would have lain in a mass for years undecomposed are, when mixed with water in a moving stream, completely rendered invisible in a few days. This has been found in a remarkable case in which the sewage of a large town, moving slowly after being mixed with an immense excess of water, has been found utterly to disappear, so that only the slightest trace of soluble matter of an organic origin could be found in it. Even the deposit gradually diminishing had ceased to be offensive, the ammonia, which was nearly a grain per gallon to begin with, could not at last be discovered, whilst the evaporation seems to have gone on in warmish weather at the rate of one grain per square foot daily. Although, therefore, water is a wonderful agent of purification, it is also an agent for the contrary, because it causes a very rapid and effervescing decomposition of organic matter, and, if in enormous quantities, it sends out impure as well as pure gases into the atmosphere. It is for that reason, apparently, that wet cesspools have been found so dangerous, and that stagnant pools are also dreaded; and for the same reason the engineers of the Board of Trade long ago determined to remove the water of water-closets out of the town as rapidly as possible, in order to prevent decomposition, and to throw it upon the land if possible at once. This was done by diminishing the size of the sewers. In experiments upon blood we find that whilst one tenth per cent. of a disinfectant is sufficient to preserve it unaffected for any length of time hitherto tried, five per cent. seems required when water is added to the blood in large quantities. The true reason of this is not very clear. It would seem as if the disinfectant either lasted only a certain time, or attacked only a limited portion of the blood, whilst the second portion by degrees assumed that condition in which it could decompose, and required to be treated separately, and so by degrees more and more of the blood underwent a change. The action of water in disinfecting within the soil is similar, but it is aided by the porous substances with which it is surrounded. It seems scarcely to be doubted that when rain washes the air it also renders it more wholesome in many respects. The unwholesome matter is washed into the ground. But this subject also requires a separate volume.

DISINFECTION—SUMMARY.

(*Written originally with especial reference to Cattle-Plague.*)

Summary of reasoning.—It is believed that the infectious matter of the plague travels in the atmosphere chiefly, and consists of minute particles.

They are organic and active.

Certain vapours and gases destroy the activity of all organic substances.

Some gases destroy the substances themselves.

The great power which certain vapours have, as shown on page 101, leads us to the belief that the matter of the cattle-plague will be prevented from change, exactly as other matter is prevented.

Mould or fungoid matter generally is either destroyed by the same vapours, or prevented from growing, showing that it yields as other organic matter.

Infusorial animals, animalcules found in putrefying liquids and in the soil, yield in a similar way, showing that they make no exception.

Matter that has begun to putrefy is caused to cease, and becomes fresh to all appearance. It may be considered as absolutely certain, that all organic substances, whether of the nature of plague or any other disease, will be arrested in their course of activity by the same substances.

The question may now be asked, Will these vapours arrest changes in living animals? They will; and living beings must all succumb under their powerful influence.

The next question is, Which will resist most, the living being or the dead one? The living animal has a power of resistance to decay that dead animal matter has not. Suppose the dead matter has a resistance of two, and the living matter a resistance of three, dead matter will decay and become diseased before living beings will yield.

But will living animals resist the destructive influence of disinfectants to a greater extent than dead matter? I believe we may answer Yes distinctly; at least for a certain time. Flesh will absorb carbolic acid as the vapour rises from it at ordinary temperatures, and become so saturated that when roasted it will cease to smell like flesh. I am informed that men working in equally strong vapour are not injured. Of course it is not desired that the vapour should be present except when danger threatens.

I am told that no foot-rot is found on ground treated with carbolic acid and lime, although previously it existed and exists still on the next fields.

The chlorine which so rapidly destroys fungoid substances had no injurious effect on men, at least during any similar length of time. Some solutions which kill infusory lives suddenly might be taken by man with ease.

All disinfectants, like medicines, are poisonous in great quantities. It is believed that there is an amount which will destroy the germs of disease aud not destroy life. If the life is very weak, it may yield before the disease. If the disease has made great advances, it will require more to destroy it than even a strong life can bear. If so, care must be taken to begin in time to crush the young life of disease when it is of a kind that disinfectants cau cure. However, these substances have hitherto beeu more fitted for prevention than cure.

It is probably easier to poison the plague by chemical means than to stamp it out by mechanism. Disinfection may be driven to the utmost, wisely in many cases; better to kill an animal by a good disinfectant, than to let it die putrid and ready to kill others.

Speaking of the cause of infection, I treat it only as represented by a substance, with form, size, and other qualities. I do not pretend to be entirely ignorant that there are theories of disease quite inconsistent with this idea. But even if I could tell anything of the more mysterious, and perhaps principal causes, I would still think it wise to study the subject of this paper. It is only when these infectious agencies approach us that we can attack them; we cannot attack them in the sun, or the planets; and whether the cause be in the stars, or whether diseases migrate like mankind from Central Asia, or are thrown down in ready-formed germs, like meteorites from space, or grow at our own unwashed back-doors, the same destruction of the agent immediate to us must take place by cleansing, or some other mode of disinfecting. Mere cleanliness is all the disinfection wanted in ordinary cases, but when epidemics arise it is quite insufficient. If our theory is true, disinfection becomes then as needful as food.

It will be to our advantage to extend the use of disinfectants, and to study them more carefully. In most cases they have been used in the form of perfumes, and frequently to mask the odour of the unwashed. For such a purpose, of course, their use is detrimental, and not innocent. All disinfectants may be viewed as medicine, and not as food. No man can breathe the vapours of any of these agents with such good effect as the pure air. They are more or less destructive of the chemical changes in organized bodies, including mankind. We have a fair hope of safety from the attacks of infected matter if it is destroyed by certain substances more readily than the living animal is destroyed. After a time it may be found that one body, say amylic alcohol, will destroy one disease, and cresylic alcohol another, whilst iodine will be required for a third. Here we make no such distinctions, but treat them, perhaps too violently, in a mass.

Hitherto, disinfection has been, and it still is, an obscure art, but I believe it destined to take a much higher place. The peculiar power, which I have called colytic, seems to point to an action by which the direction of the forces in compounds is changed, and may lead to some interesting scientific investigations.

Substances best suited for preventing decomposition.—Acid metallic salts seem so well qualified for this *when water is present* that they may be said to stand first.

Of these, again, chloride of zinc stands so high that it may be called the first. The chloride of mercury and sulphate of copper are perhaps superior, but are too expensive for general use. Chloride of iron stands high.

Common salt stands very high by this test, and as it can be had for a small price it will no doubt be more used.

I made an attempt to estimate the money value of disinfectants, with the following result :—

Disinfectant.	Substance.	Value.			Relative Expense of Disinfectants, Salt being considered 1.
		£	s	d.	
100 lb.	Salt, . . .	0	0	5	1
7 lb.	Cresylic acid, .	0	2	0⅓	4·9
23·2 lb.	Chloride of lime, .	0	2	10¾	7
70 lb.	M'Dougall's powder,	0	5	10	14
9·3 lb.	Carbolic acid, .	0	5	10	14

This is the true form to which the whole question must be reduced ; but, as already stated, the circumstances of each are different, and this calculation suits only prevention of decomposition when water is present in small quantities. The value of common salt is put low, but rock salt could be got at this price.

This table was lost in the hurry of getting the Cattle-Plague Report ready. I think it rude, but it may grow more refined.

Sulphites are excellent disinfectants, and remove the most offensive part of the smell rapidly. If, however, they are allowed to stand long in water they decompose, and give out sulphuretted hydrogen. Sulphites are best used along with the tar acids. The substances disinfected with it ought to be removed in at least three days, and better if every day.

Chloride of lime has not a good preserving power, but a great destructive power, and permanganate of potash, Condy's fluid, destroys without smell.

The tar acids, otherwise carbolic alcohol and cresylic alcohol or acid, are excellent disinfectants in all cases, but are not equal in water to the metallic chlorides mentioned.

Disinfection where there is little moisture.—In this case the tar acids do not seem to have any rivals, so little is sufficient for the purpose. Dry sulphites mixed with them are an improvement, but of themselves they have a marvellous power of preventing decomposition.

The use of fusel oil, etc., has been mentioned. For particulars see the Tables.

For disinfection when putrefaction has advanced, and the smell is to be removed.—There is perhaps nothing superior or even equal to chloride of lime in this case, unless we except peroxide of hydrogen and permanganate of potash, which are expensive.

If, however, it is not desired to destroy the manure or to leave the mixture moist, it is necessary to try something else, viz.—

A mixture of sulphites is good for this purpose with tar acids, but the action is not so rapid or violent as with chloride of lime.

Fumigation.—This is done by—

Chlorine,
Sulphurous acid,
The tar acids chiefly.

Chlorine is made by pouring muriatic acid on black oxide of manganese, or on chloride of lime. Chlorate of potash and muriatic acid give a mixed and powerful vapour. The first plan is probably the cheapest. A very faint trace ought to be kept in the atmosphere, but it ought to be constant at first, and when the cattle are absent it may be used in great excess.

Sulphurous acid is made by burning sulphur.

The tar acids are by far the most manageable, and give least trouble. They require only to be laid down, when they evaporate gradually and fill the air.

Sulphurous acid and tar acids can be used together if desired, but sulphur cannot be used with chlorine or chloride of lime.

An excellent way to make chlorine is to mix about 1 lb. of chloride of lime with 1½ lb. of potash alum, or of alum cake well pounded. Ammonia alum will not do. The chlorine is given off gradually. Another plan, recommended by Mr. Stone of Manchester, is to throw a crystal of chlorate of potash into a stone or glass dish containing muriatic acid, when it gradually dissolves and gives off chlorine. The amount must be regulated by the sense of smell. There must be a distinct odour in the cowhouses. A difficulty occurs here. Carbolic acid and cresylic acid can be used in-doors and out of doors, and it is difficult to remove the smell; this chlorine fumigation is not so easily transferred, and it is not clear how to fumigate well the yard and the fold as well as the large masses of manure lying in the fold with any vapours but those of tar acids. For very impure places muriatic acid and black oxide of manganese may be used, but great quantities would be required.

TREATMENT OF DEAD CATTLE TO BE PRESERVED FOR MANURE.

About twenty years ago a young surgeon from the Isle of Man, named Cookson, adopted a plan of preserving swine in America, by injecting the blood-vessels with brine. It was carried out for a time by Messrs. Thomas and Frank Jewsbury of Manchester. The operation could be performed in a few minutes on a whole animal. Dr. Morgan of Dublin has renewed the method with improvements, and it may be seen carried out in that city, both on human beings and the lower animals. The success of this is complete. He adds, potash salts, nitrate of potash, and phosphorous acid, chiefly.

"The animal is killed by a blow on the head, piercing the brain, and causing instantaneous death. The chest is then at once opened, and the heart exposed. An incision is made into the right side of it, either the right ventricle or auricle, —and directly another into the left side (the left ventricle); the blood from the right side (venous), and from the left (arterial), immediately rushes out. When it has ceased flowing, a pipe is introduced into the incision in the left ventricle, —and so into the aorta, or great vessel leading through the body, *i.c.*, the trunk of the circulatory tree, and is there firmly retained. This pipe can be connected by a coupling with a stop-cock fixed to a flexible tubing, 20 to 25 feet long, and this tubing communicates with a tank raised the height of the length of the tube, into which brine and a little nitre is put when well strained (about one gallon to the hundredweight). The stop-cock is connected to the pipe in the aorta, and the fluid let on; it will rush out at the incision in the right side of the heart, after traversing all the circulatory organs, in four or five *seconds* in sheep, swine, and such like,—and in nine or twelve *seconds* in oxen, and in two minutes or so in the latter, and proportionately less in the former, will have run through —thereby clearing the vessels and capillaries, and preparing for the second stage, which is performed simply by closing the incision in the right side with a strong sliding forceps, and thereby rendering the circulatory system perfect, as originally, but with the vessels free and ready to receive the preservative fluid."

But although I speak of these things as recent, the method is in principle older. We have apparently only to enter Dr. Morgan's dissecting-room, where numerous bodies lie, entirely without odour, to be convinced that the process is effective, and may in many cases be carried out. Mr. Stone of Manchester says it has been adopted at the Manchester School of Medicine for a longer time, so far as the mechanism is concerned.

The same process may be practised on condemned cattle.

A workman can learn the process rapidly; a moveable pump could be used as the instrument for injecting the preserving fluid. A stronger than Dr. Morgan's may be used. The mere mechanical method of treatment is to my mind a wasteful destruction of matter most valuable as manure. By this simple mode of disinfecting, we may obtain, at least, something worth preserving amongst the ruins of our cattle. The outside may be treated as hides are, and the blood run off into the nearest land and disinfected. Rather than bury such an amount of precious phosphates and ammonia, it might be sufficient to saturate the animal with muriatic acid, the very efficient, cheap, and penetrating disinfectant of Guyton Morveau, more valuable probably for this purpose than for fumigation. The carcase could then be taken, to be converted into manure, without fear of communicating disease.

Mr. Gamgee's mode of killing cattle by causing them to inhale carbonic oxide seems to offer the best solution, if the accounts we hear are correct. Not much of the process is yet known to the public. If it is good for preserving cattle to be used as food, it will also be good for the above purpose. He uses a little sulphurous acid at the same time.

APPENDIX.

DISINFECTANTS FOR DOMESTIC USE.

Every one must pick out the cheapest and most convenient disinfectant according to the circumstances of the case. For closets, salts of metals, that is, chloride and sulphate of iron or zinc, or carbolic acid. Some people object to that acid. A nurse in a London infirmary preferred the smell of skin diseases. The salts may be put in the cistern occasionally, or be poured down occasionally. Carbolic acid may be used with abundance of water if it does not stand still for many days.

My belief is strong in common salt. The laboratory experiments bear much in its favour. I have neglected however to try it on a large scale, and must wait till it is tried. For constant use, antiseptics or colytics that prevent decomposition are best, even although they do not destroy smells already formed. Chloride of lime has been repeatedly said to be the most destructive when decomposition is already present, and Condy's fluid permanganate still more elegantly so.

Carbolic acid is most easily and cheaply managed when people don't object to the smell. It may be remembered that, as a rule, where we smell it we are safe from objectionable organic matter. Such is the belief.

DIRECTIONS.

The following results have been obtained after many trials, but it is impossible to be exact, as the conditions of the substances differ. These sentences were prepared in answer to questions sent to me during the cattle-plague :—

Solid substances containing little moist matter and little organic matter are disinfected by very weak solutions.

Bones dried, but musty, were disinfected by 1 of cresylic acid, carbolic acid, or of chloride of lime to 1000 of water. They stood about a day. With 1 per cent. the action is in a few minutes.

One per cent. of chloride of lime in water is not enough for flesh and such solid matters. Five per cent. is abundant. Stronger solutions are not wanted, except when great haste is required in very bad cases.

Here is a short summary :—

Chloride of lime destroys smell rapidly.

Condy's fluid permanganate for in-doors when no smell is allowed even of the disinfectant.

Tar acids for continuous action, and especially for the air in all places.

Chloride of lime—Burnett's fluid—for preserving moist bodies long.

1. Dry cattle skins—May be disinfected with cresylic or carbolic acids, 2 oz. being mixed with 1 gallon of water, and used so as to wet them, or sprinkled with chloride of lime (sol. A.)
2. Dry horn tips—Should be moistened with a solution of 2 lbs. of common salt to the gallon of water, having mixed with it about 3 oz. of cresylic or carbolic acids, or washed with a solution of chloride of lime containing 1 lb. of the same in 2 gallons of water. These, although not apt to rot, may be touched with hurtful matter during a time of plague.
3. Salted and dry cattle gut—If salted, without disinfection.
4. Melted tallow in casks—Washed with the common salt and carbolic acid solution mentioned above (sol. A.)
5. Cows' hair—Cresylic or carbolic acid in the proportion

of 1 oz. to the cwt. should be diffused through the material.

6. Pigs' bristles—The same as cows' hair.
7. Sheep's wool in bags—A little carbolic acid poured in will soon pervade the whole mass; also sheep-dip such as M'Dougall's.
8. Whole horns—Should be washed with sol. A., or sprinkled with chloride of lime, ½ lb. to the cwt.
9. Hoofs—The same.
10. Melted tallow in skins—Should be moistened outside with sol. A, or washed with disinfecting soap.
11. Fresh bones—Very difficult to treat. The mode less likely to injure for subsequent purposes is heating to 200° F., but if this cannot be done, washing with a solution of one part of cresylic or carbolic acid in 100 parts of water will produce little injury in the subsequent manufacture, and will disinfect.
12. Fresh skins—May have common salt spread over them for 12 hours, and afterwards be washed with water containing 2 oz. of carbolic or cresylic acid to the gallon, or laid in a solution of chloride of lime, ½ lb. to the gallon of water for 10 minutes, or in a solution with 2 lbs. to the gallon for a few seconds, or with ¼ lb. to the gallon and 3 oz. of muriatic acid.
13. Fresh guts—May be treated with salt in the state of powder, together with carbolic or cresylic acid, the latter being in the proportion of 2 oz. to the cwt.
14. Raw flesh—May be salted, and treated with the carbolic or cresylic acid solution, if not to be used for food, or the acids may be used without water.
15. Raw sheep skins—May be treated with sheep-dip or soap, if there be wool on them, or perhaps soap and carbolic acid.

For the following articles an additional quantity of carbolic acid might be recommended in bad cases :—

16. Waggons—May be washed with solution of carbolic acid or with disinfecting soap, or with soda, or lime and carbolic acid.

Platforms—The same.

17. Articles used at places where the disease is known to have existed—The same.
18. Ships—The same, or instead of this soap, tar acid and caustic soda, which mixture may be made stronger than the soap.
19. Pens—Treated as cowsheds.

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